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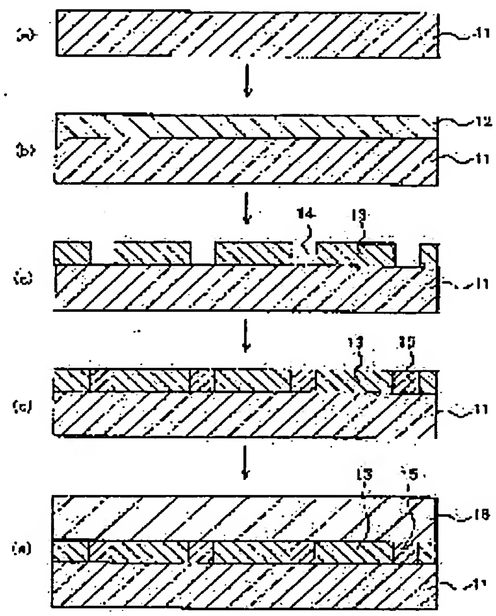
(71)Applicant : MATSUSHITA ELECTRIC IND CO LTD
(72)Inventor : UMETANI MAKOTO
KORENAGA TSUGUHIRO

(54) OPTICAL WAVEGUIDE SUBSTRATE, METHOD OF MANUFACTURING THE SAME, OPTICAL WAVEGUIDE PARTS AND METHOD OF MANUFCTURING THE SAME

(57)Abstract:
PROBLEM TO BE SOLVED: To provide the structure of an optical waveguide substrate having cores in a fine pattern which hardly cause decrease in transfer accuracy during forming the cores due to thermal expansion and a method of manufacturing the optical waveguide substrate.
SOLUTION: A UV-curing resin 12 is applied onto a lower clad layer 11 made of a planar glass substrate. The UV-curing resin 12 is hardened by irradiation with UV rays through the back face of a die which has linear projections of the core pattern and transmits UV rays so as to form an intermediate clad layer 13 having grooves 14. Then the grooves 14 are filled with a transparent resin having a different refractive index to form the cores 15. Then an upper clad layer 17 made of a planar glass substrate is fixed thereto to manufacture the optical waveguide substrate.



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CLAIMS

[Claim(s)]
[Claim 1] Are the manufacture approach of the optical waveguide substrate which restrains a light beam by incore and is made to spread in accordance with the shaft of said core, and the glass substrate of a refractive index n1 is processed into a predetermined configuration. The process which obtains the lower cladding layer which makes one flat surface an optical plane of composition, and the process which applies to the optical plane of composition of said lower cladding layer the ultraviolet-rays hardening resin which has a refractive index n2, the line which has the same configuration as said core -- the mold which penetrates the ultraviolet rays in which heights were formed -- using -- said ultraviolet-rays hardening resin -- pressing -- said type of line -- with the process which makes heights contact the optical plane of composition of said lower cladding layer The process which obtains the middle cladding layer in which the slot which releases said mold from mold and serves as space of said core after stiffening said ultraviolet-rays hardening resin by irradiating ultraviolet rays from said type of rear face was formed, Said slot of said middle cladding layer is filled up with the transparence resin which has a refractive index n3 (n3> n2, n1). The manufacture approach of the optical waveguide substrate characterized by having the process which forms an up cladding layer in the top face of the process which obtains said core by making it harden, and said middle cladding layer after said core was formed by joining the flat-surface glass substrate which has a refractive index n4 (n4<n3).
[Claim 2] The lower cladding layer which is the optical waveguide substrate which restrains a light beam by incore and is made to spread in accordance with the shaft of said core, and consists of a flat-surface glass substrate of a refractive index n1, The middle cladding layer in which the slot which is pinched by the up cladding layer which consists of a flat-surface glass substrate of a refractive index n4, and said lower cladding layer and said up cladding layer, consists of ultraviolet-rays hardening resin which has a refractive index n2, and serves as space of said core was established, The optical waveguide substrate characterized by having said core which the slot of said middle cladding layer was made to fill up with and harden the transparence resin which has a refractive index n3 (n3> n4, n2, n1), and was obtained.
[Claim 3] Are the manufacture approach of optical waveguide components of combining the optical waveguide substrate which restrains a light beam by incore and is made spreading in accordance with the shaft of said core, and an optical fiber, and the glass substrate of a refractive index n1 is processed into a predetermined configuration. the line for forming the process which obtains the glass substrate for [fabricated] which makes one flat surface an optical plane of composition, and the fixed slot of said optical fiber, while pressing said glass substrate for [fabricated] using the press die in which the crest type projection was formed While making it soften by heating said glass substrate for [fabricated] and forming said fixed slot in said some of glass substrates for [fabricated] The process which forms a lower cladding layer in other parts of said glass substrate for [fabricated], The process which applies to the top face of the lower cladding layer of said glass substrate for [fabricated] the ultraviolet-rays hardening resin which has a refractive index n2, The mold which penetrates the ultraviolet rays in which heights were formed is used. the line which has the same configuration as said core -- said line -- the center line of the fixed slot of heights and said optical fiber is in agreement -- as -- said ultraviolet-rays hardening resin -- pressing -- said type of line -- with the process which makes heights contact the flat-surface part of the lower cladding layer of said glass substrate for [fabricated] The process which obtains the middle cladding layer in which the slot which opens said mold wide and serves as space of said core after stiffening said ultraviolet-rays hardening resin by irradiating ultraviolet rays from said type of rear face was formed, The process which obtains said core by making the slot of said middle cladding layer fill up with and harden the transparence resin which has a refractive index n3 (n3> n2, n1), The manufacture approach of the optical waveguide components characterized by having the process which forms an up cladding layer in the top face of the middle cladding layer after said core was formed by joining the flat-surface glass substrate which has a refractive index n4 (n4<n3).
[Claim 4] They are the optical waveguide components which combine the optical waveguide substrate which restrains a light beam by incore and is made to spread in accordance with the shaft of said core, and an optical fiber. The lower cladding layer which consists of a glass substrate of a refractive index n1 and by which the optical plane of composition was formed in said some of glass substrates, and the base substrate which has the optical fiber joint by which the fixed slot of said optical fiber was formed in other parts of said glass substrate, The middle cladding layer by which it was prepared in the optical plane of composition of the lower cladding layer of said base substrate, and the slot which consists of ultraviolet-rays hardening resin which has a refractive index n2, and serves as space of said core was prepared on the production of the fixed slot of said optical fiber, Said core which the slot of said middle cladding layer was made to fill up with and harden the transparence resin which has a refractive index n3 (n3> n2, n1), and was obtained, The optical waveguide components characterized by having the up cladding layer which joined the flat-surface glass substrate which has a refractive index n4 (n4<n3) to said core and top face of a middle cladding layer, and was formed in them.
[Claim 5] Are the manufacture approach of the optical waveguide substrate which restrains a light beam by incore and is made to spread in accordance with the shaft of said core, and the glass substrate of a refractive index n1 is processed into a predetermined configuration. The process which obtains the lower cladding layer which makes one flat surface an optical plane of composition, and the process which applies to the optical plane of composition of said lower cladding layer the ultraviolet-rays hardening resin which has a refractive index n2 (n2> n1), the line which has the same configuration as said core -- the mold which penetrates the ultraviolet rays in which the crevice was formed -- using -- said ultraviolet-rays hardening resin -- pressing -- said type of line -- with the process which makes the flat-surface section except a crevice contact the optical plane of composition of said lower cladding layer By stiffening said ultraviolet-rays hardening resin and opening said mold from a press condition by irradiating ultraviolet rays from said type of rear face The process which forms said core in the top face of said

lower cladding layer, and by applying and stiffening the transparence resin which has a refractive index n3 (n3<n2) so that said core may be wrapped in The manufacture approach of the optical waveguide substrate characterized by having the process which forms a plate-like up cladding layer, and the process which forms the flat-surface glass substrate for protection in the top face of said up cladding layer.

[Claim 6] The lower cladding layer which is the optical waveguide substrate which restrains a light beam by incore and is made to spread in accordance with the shaft of said core, and consists of a flat-surface glass substrate of a refractive index n1, Said core formed in the top face of said lower cladding layer convex using the ultraviolet-rays hardening resin which has a refractive index n2 (n2> n1), The optical waveguide substrate characterized by having the up cladding layer formed in plate-like by applying and stiffening the transparence resin which has a refractive index n3 (n3<n2) so that said core may be wrapped in, and the flat-surface glass substrate for protection formed in the top face of said up cladding layer.

[Claim 7] Are the manufacture approach of optical waveguide components of combining the optical waveguide substrate which restrains a light beam by incore and is made spreading in accordance with the shaft of said core, and an optical fiber, and the glass substrate of a refractive index n1 is processed into a predetermined configuration. the line for forming the process which obtains the glass substrate for [fabricated] which makes one flat surface an optical plane of composition, and the fixed slot of said optical fiber, while pressing said glass substrate for [fabricated] using the press die in which the crest type projection was formed While making it soften by heating said glass substrate for [fabricated] and forming the fixed slot of said optical fiber in said some of glass substrates for [fabricated] The process which forms a lower cladding layer in other parts of said glass substrate for [fabricated], The process which applies to the top face of the lower cladding layer of said glass substrate for [fabricated] the ultraviolet-rays hardening resin which has a refractive index n2 (n2> n1), The mold which penetrates the ultraviolet rays in which the crevice was formed is used. the line which has the same configuration as said core — said line — said ultraviolet-rays hardening resin being pressed so that the center line of a crevice and the fixed slot of said optical fiber may be in agreement, and with the process which makes the flat-surface section except said type of crevice contact the top face of said lower cladding layer By stiffening said ultraviolet-rays hardening resin and opening said mold from a press condition by irradiating ultraviolet rays from said type of rear face The process which forms said core in the top face of said lower cladding layer, and by applying the transparence resin which has a refractive index n3 (n3<n2) so that said core may be wrapped in The manufacture approach of the optical waveguide components characterized by having the process which forms a plate-like up cladding layer, and the process which forms the flat-surface glass substrate for protection in the top face of said up cladding layer.

[Claim 8] They are the optical waveguide components which combine the optical waveguide substrate which restrains a light beam by incore and is made to spread in accordance with the shaft of said core, and an optical fiber. The lower cladding layer which consists of a glass substrate of a refractive index n1 and by which the optical plane of composition was formed in said some of glass substrates, and the base substrate which has the optical fiber joint by which the fixed slot of said optical fiber was formed in other parts of said glass substrate, Said core formed in convex so that it might be prepared in the top face of the lower cladding layer of said base substrate, and it might consist of ultraviolet-rays hardening resin which has a refractive index n2 (n2> n1) and might be in agreement with the production of the fixed slot of said optical fiber, By applying and stiffening the resin which has a refractive index n3 (n3<n2) so that said core may be wrapped in The optical waveguide components characterized by having the up cladding layer formed in plate-like, and the flat-surface glass substrate for protection formed by joining a glass substrate to the top face of said up cladding layer.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the optical waveguide component for it being highly precise and connecting a reliable optical waveguide substrate and its reliable manufacture approach, and an optical fiber which can be manufactured by the cheap approach, and its manufacture approach.
[0002]
[Description of the Prior Art] Drawing 13 is the sectional view showing the structure of the optical waveguide substrate of a general quartz system single mode. It is shown to a light beam to this optical waveguide substrate at the part of core 122a with a refractive index higher than the lower cladding layer 121 and the up cladding layer 123, and it has composition which a light beam spreads to the shaft orientations of optical waveguide.
[0003] Such a manufacture approach of the conventional optical waveguide substrate is explained using drawing 14 . As shown in drawing 14 (a), the flame depositing method etc. is used on the quartz substrate which served as the lower cladding layer 121, the optical material 122 with a refractive index higher than the lower cladding layer 121 is formed, and it changes into a condition like drawing 14 (b). Next, by the dry etching method, an optical material 122 is processed into the pattern of a predetermined core, and core 122a is formed in the photograph RISOGURAFU method list like drawing 14 (c). Finally, as shown in drawing 14 (d), the method of wrap up cladding layer 123 is formed, and an optical waveguide substrate is made to core 122a. as the bibliography which indicated such a manufacture approach -- the Kawachi work, optronics, and No. -- there are 8, 85, and 1988 grades.
[0004] On the other hand, shaping is easy although the penetrable ability and dependability of light are inferior in a resin ingredient compared with a quartz. For this reason, the optical waveguide substrate using resin is also examined in order to attain low cost-ization of an optical waveguide substrate. The manufacture approach of the optical waveguide substrate made of resin carries out sequential formation of a cladding layer and the core layer, like manufacture of the optical waveguide substrate made from a quartz, carries out patterning of the core by the dry etching method, and manufactures it.
[0005] However, when a FOTORISO graphic method and the dry etching method are used for patterning of a core, much complicated and highly precise facilities are needed. Therefore, in having manufactured the optical waveguide substrate by such approach, although the ingredient is cheap, it is difficult to manufacture an optical waveguide substrate cheaply substantially.
[0006] Recently, the manufacture approach of an optical waveguide substrate as shown in drawing 15 is used as indicated by JP,8-320420,A. By this manufacture approach, as shown in drawing 15 (a), using the moldings 131-ed which consists of thermoplastics like glass, heating softening of this is carried out and it is made plate-like. Next, as shown in drawing 15 (b), press forming is carried out by the press die which has the reversal configuration (heights) of a core pattern, and a moldings is taken out after cooling. If it carries out like this, the imprint of a core pattern will be performed and crevice 131a will be formed. In order to use this plate-like member as an optical waveguide substrate, as shown in drawing 15 (c), the resin 132 with which refractive indexes differ is embedded at crevice 131a. Next, as shown in drawing 15 (d), the substrate used as the up cladding layer 133 is formed in the top face of the lower cladding layer 134, and an optical waveguide substrate is produced.
[0007]
[Problem(s) to be Solved by the Invention] However, by such imprint approach, since the moldings-ed which carried out heating softening is contacted to a press die and it cools, it originates in the difference of the coefficient of thermal expansion of a moldings-ed and a press die, and thermal stress occurs. Consequently, the precision of the pattern imprinted by the moldings-ed falls. A pattern gap becomes large, so that distance becomes long towards the core of a press die to a periphery especially. Since the coefficient of thermal expansion is large figures about double [1-] compared with ingredients, such as a quartz used as an ingredient of a mold, especially when a resin ingredient is used for a moldings-ed, when severe, a resin ingredient comes to be scooped out by the press die.
[0008] If it imprints to a resin substrate using a press die according to the place which this invention person actually examined concretely, the shape of breadth and a quirk will have been confused by the width of face of a slot on the level of micron order. It is thought that this phenomenon is the result of a resin substrate's contracting more greatly than a press die at the time of cooling, and a resin substrate contracting toward that imprint center section. Thus, the resin ingredient had the advantage which can be fabricated at low temperature, and although the manufacturing-cost top was also advantageous, when it was going to imprint the pattern by press forming, it had a problem of it becoming impossible to imprint a detailed pattern correctly.
[0009] Moreover, when the whole optical waveguide substrate was constituted from resin, since the coefficient of thermal expansion was large, the optical waveguide pattern deformed by the surrounding temperature change, and the technical problem that dependability was no longer secured enough occurred.
[0010] Without being made in view of such a conventional trouble, and using the fabricating method between the conventional heat, this invention uses ultraviolet-rays hardening resin for a middle cladding layer or a core, prevents the fall of the imprint precision resulting from thermal expansion, and aims at realizing the optical waveguide components and those manufacture approaches for connecting the optical waveguide substrate and optical fiber which have the core of a detailed pattern.
[0011]
[Means for Solving the Problem] The optical waveguide substrate of this invention is an optical waveguide substrate which restrains a light beam by incore and is made to spread in accordance with the shaft of said core. Moreover, the optical waveguide components of this invention are optical waveguide components which combine the optical waveguide substrate which restrains a light beam by incore and is made to spread in accordance with the shaft of said core, and an optical fiber. The manufacture

approach of this invention is an approach of manufacturing those optical waveguide substrates or optical waveguide components.

[0012] The manufacture approach of the 1st optical waveguide substrate of this invention processes the glass substrate of a refractive index n1 into a predetermined configuration. The process which obtains the lower cladding layer which makes one flat surface an optical plane of composition, and the process which applies to the optical plane of composition of said lower cladding layer the ultraviolet-rays hardening resin which has a refractive index n2, the line which has the same configuration as said core -- the mold which penetrates the ultraviolet rays in which heights were formed -- using -- said ultraviolet-rays hardening resin -- pressing -- said type of line -- with the process which makes heights contact the optical plane of composition of said lower cladding layer The process which obtains the middle cladding layer in which the slot which releases said mold from mold and serves as space of said core after stiffening said ultraviolet-rays hardening resin by irradiating ultraviolet rays from said type of rear face was formed, Said slot of said middle cladding layer is filled up with the transparence resin which has a refractive index n3 (n3> n2, n1). It has the process which forms an up cladding layer in the top face of the process which obtains said core, and said middle cladding layer after said core was formed by joining the flat-surface glass substrate which has a refractive index n4 (n4<n3) by making it harden.
[0013] The lower cladding layer which the 1st optical waveguide substrate of this invention becomes from the flat-surface glass substrate of a refractive index n1, The middle cladding layer in which the slot which is pinched by the up cladding layer which consists of a flat-surface glass substrate of a refractive index n4, and said lower cladding layer and said up cladding layer, consists of ultraviolet-rays hardening resin which has a refractive index n2, and serves as space of said core was established, It has said core which the slot of said middle cladding layer was made to fill up with and harden the transparence resin which has a refractive index n3 (n3> n4, n2, n1), and was obtained.
[0014] The manufacture approach of the 1st optical waveguide component of this invention processes the glass substrate of a refractive index n1 into a predetermined configuration. the line for forming the process which obtains the glass substrate for [fabricated] which makes one flat surface an optical plane of composition, and the fixed slot of said optical fiber, while pressing said glass substrate for [fabricated] using the press die in which the crest type projection was formed While making it soften by heating said glass substrate for [fabricated] and forming said fixed slot in said some of glass substrates for [fabricated] The process which forms a lower cladding layer in other parts of said glass substrate for [fabricated], The process which applies to the top face of the lower cladding layer of said glass substrate for [fabricated] the ultraviolet-rays hardening resin which has a refractive index n2, The mold which penetrates the ultraviolet rays in which heights were formed is used. the line which has the same configuration as said core -- said line -- the center line of the fixed slot of heights and said optical fiber is in agreement -- as -- said ultraviolet-rays hardening resin -- pressing -- said type of line -- with the process which makes heights contact the flat-surface part of the lower cladding layer of said glass substrate for [fabricated] The process which obtains the middle cladding layer in which the slot which opens said mold wide and serves as space of said core after stiffening said ultraviolet-rays hardening resin by irradiating ultraviolet rays from said type of rear face was formed, The process which obtains said core by making the slot of said middle cladding layer fill up with and harden the transparence resin which has a refractive index n3 (n3> n2, n1), It has the process which forms an up cladding layer in the top face of the middle cladding layer after said core was formed by joining the flat-surface glass substrate which has a refractive index n4 (n4<n3).
[0015] The 1st optical waveguide component of this invention consists of a glass substrate of a refractive index n1. The lower cladding layer by which the optical plane of composition was formed in said some of glass substrates, and the base substrate which has the optical fiber joint by which the fixed slot of said optical fiber was formed in other parts of said glass substrate, The middle cladding layer by which it was prepared in the optical plane of composition of the lower cladding layer of said base substrate, and the slot which consists of ultraviolet-rays hardening resin which has a refractive index n2, and serves as space of said core was prepared on the production of the fixed slot of said optical fiber, It has the up cladding layer which joined the flat-surface glass substrate which has a refractive index n4 (n4<n3) to said core which the slot of said middle cladding layer was made to fill up with and harden the transparence resin which has a refractive index n3 (n3> n2, n1), and was obtained, said core, and the top face of a middle cladding layer, and was formed in them.
[0016] The manufacture approach of the 2nd optical waveguide substrate of this invention processes the glass substrate of a refractive index n1 into a predetermined configuration. The process which obtains the lower cladding layer which makes one flat surface an optical plane of composition, and the process which applies to the optical plane of composition of said lower cladding layer the ultraviolet-rays hardening resin which has a refractive index n2 (n2> n1), the line which has the same configuration as said core -- the mold which penetrates the ultraviolet rays in which the crevice was formed -- using -- said ultraviolet-rays hardening resin -- pressing -- said type of line -- with the process which makes the flat-surface section except a crevice contact the optical plane of composition of said lower cladding layer By stiffening said ultraviolet-rays hardening resin and opening said mold from a press condition by irradiating ultraviolet rays from said type of rear face The process which forms said core in the top face of said lower cladding layer, and by applying and stiffening the transparence resin which has a refractive index n3 (n3<n2) so that said core may be wrapped in It has the process which forms a plate-like up cladding layer, and the process which forms the flat-surface glass substrate for protection in the top face of said up cladding layer.
[0017] The lower cladding layer which the 2nd optical waveguide substrate of this invention becomes from the flat-surface glass substrate of a refractive index n1, Said core formed in the top face of said lower cladding layer convex using the ultraviolet-rays hardening resin which has a refractive index n2 (n2> n1), It has the up cladding layer formed in plate-like, and the flat-surface glass substrate for protection formed in the top face of said up cladding layer by applying and stiffening the transparence resin which has a refractive index n3 (n3<n2) so that said core may be wrapped in.
[0018] The manufacture approach of the 2nd optical waveguide component of this invention processes the glass substrate of a refractive index n1 into a predetermined configuration. the line for forming the process which obtains the glass substrate for [fabricated] which makes one flat surface an optical plane of composition, and the fixed slot of said optical fiber, while pressing said glass substrate for [fabricated] using the press die in which the crest type projection was formed While making it soften by heating said glass substrate for [fabricated] and forming the fixed slot of said optical fiber in said some of glass substrates for [fabricated] The process which forms a lower cladding layer in other parts of said glass substrate for [fabricated], The process which applies to the top face of the lower cladding layer of said glass substrate for [fabricated] the ultraviolet-rays hardening resin which has a refractive index n2 (n2> n1), The mold which penetrates the ultraviolet rays in which the crevice was formed is used. the line which has the same configuration as said core -- said line -- said ultraviolet-rays hardening resin being pressed so that the center line of a crevice and the fixed slot of said optical fiber may be in agreement, and with the process which makes the flat-surface section except said type of crevice contact the top face of said lower cladding layer By stiffening said

ultraviolet-rays hardening resin and opening said mold from a press condition by irradiating ultraviolet rays from said type of rear face The process which forms said core in the top face of said lower cladding layer, and by applying the transparence resin which has a refractive index n3 (n3<n2) so that said core may be wrapped in It has the process which forms a plate-like up cladding layer, and the process which forms the flat-surface glass substrate for protection in the top face of said up cladding layer.

[0019] The 2nd optical waveguide component of this invention consists of a glass substrate of a refractive index n1. The lower cladding layer by which the optical plane of composition was formed in said some of glass substrates, and the base substrate which has the optical fiber joint by which the fixed slot of said optical fiber was formed in other parts of said glass substrate, Said core formed in convex so that it might be prepared in the top face of the lower cladding layer of said base substrate, and it might consist of ultraviolet-rays hardening resin which has a refractive index n2 (n2> n1) and might be in agreement with the production of the fixed slot of said optical fiber, By applying and stiffening the resin which has a refractive index n3 (n3<n2) so that said core may be wrapped in, it has the up cladding layer formed in plate-like, and the flat-surface glass substrate for protection formed by joining a glass substrate to the top face of said up cladding layer.

[0020]

[Embodiment of the Invention] Hereafter, it explains, referring to a drawing about the gestalt of each operation of this invention.

[0021] (Gestalt 1 of operation) The structure and its manufacture approach of the optical waveguide substrate in the gestalt 1 of operation of this invention are explained using drawing 1 - drawing 4 . An optical waveguide substrate restrains a light beam by incore, and is made to spread it in accordance with the shaft of a core. Drawing 1 is outline process drawing of the manufacture approach of the optical waveguide substrate in the gestalt of this operation. As shown in drawing 1 (a), the lower cladding layer 11 which consists of a flat-surface glass substrate of a refractive index n1 is fixed horizontally, and as shown in drawing 1 (b), ultraviolet-rays hardening resin 12 is applied to the top face which is an optical plane of composition of the lower cladding layer 11. This ultraviolet-rays hardening resin 12 has a refractive index n2.

[0022] next, the location equivalent to a core -- a line -- by creating beforehand the mold (not shown) which penetrates the ultraviolet rays which have heights, pressing ultraviolet-rays hardening resin 12 with the mold, and irradiating ultraviolet rays from the rear face of a mold, ultraviolet-rays hardening resin 12 is stiffened and a mold is released from mold. If it does so, as shown in drawing 1 (c), the middle cladding layer 13 which has the slot 14 equivalent to a core by the same thickness as a core will be formed. And as shown in drawing 1 (d), a slot 14 is filled up with the transparence resin of a refractive index n3 (n3> n2, n1), and a core 15 is formed. The up cladding layer 16 which consists of a flat-surface glass substrate which moreover has a refractive index n4 (n4<n3) as shown in drawing 1 (e) is formed, and an optical waveguide substrate is completed.

[0023] Drawing 2 is the sectional view showing the black light 20 used for the hardening process of ultraviolet-rays hardening resin 12 in the manufacture approach of the gestalt this operation. Drawing 2 shows the condition before hardening. a line for the mold 21 which penetrates ultraviolet rays to form a core -- it is the mold made from a quartz which has heights 21a. this line -- in the example based on the gestalt of this operation, after heights 21a ground the quartz-glass substrate 5mm in thickness, and 5mm wide [5mm long and] at the flat surface, it was formed by the patterning method using the usual photoresist. the dry etching method after forming a band-like pattern to a quartz-glass substrate in the example -- using -- a quartz-glass substrate front face -- a line -- four heights 21a (cross-section configuration; projection with a height [of 8 micrometers] x width of face of 8 micrometers) was prepared at intervals of 250 micrometers.

[0024] On the other hand, the flat-surface glass substrate used as a lower cladding layer 11 is what was ground at the flat surface 2mm in thickness, and 5mm wide [5mm long and], and has the property of refractive-index n1=1.5, and coefficient-of-thermal-expansion 70x10-7/K. The ultraviolet-rays hardening resin 12 which has the refractive index n2 same [11] as this lower cladding layern1 was applied by the thickness of homogeneity by spin coating. Then, after applying a release agent to the mold 21 made from a quartz mentioned above, the mold 21 was carried on ultraviolet-rays hardening resin 12, and it placed on the bottom block 22.

[0025] In this condition, the upper block 23 which built in the light source 24 which generates ultraviolet rays was dropped gradually, and the pressure was applied and pressed. it is shown in drawing 3 -- as -- the line of the mold 21 made from a quartz -- press is continued until it touches the front face of the lower cladding layer 11, and after the tip of heights 21a irradiated ultraviolet rays and stiffened ultraviolet-rays hardening resin 12 from the rear face of a mold 21, it made the mold 21 release from mold As the substrate at this time was shown in drawing 3 , on the lower cladding layer 11, it is the same thickness as a core and the middle cladding layer 13 which has a slot equivalent to a core was formed. In this substrate, it dissociates mutually with a core and the middle cladding layer 13 has band-like. Since the further band-like middle cladding layer 13 was firmly pasted up on the lower cladding layer 11, the pattern gap with a mold 21 and the middle cladding layer 13 became very small, and the configuration of a mold 21 was imprinted good as it was.

[0026] Then, as shown in drawing 1 (c) and (d), the transparence resin made from epoxy which has the refractive index n3 higher about 0.3% than the middle cladding layer 13 was embedded in the formed slot 14, and the core 15 was formed in it like drawing 1 (d). And the up cladding layer 16 which consists of the same flat-surface glass substrate as the lower cladding layer 11 was further stuck from the upper part. Thus, the optical waveguide substrate shown in drawing 4 was produced.

[0027] This optical waveguide substrate used the epoxy resin as the core 15, made the flat-surface glass substrate the up cladding layer 16 and the lower cladding layer 11, and is equipped with ultraviolet-rays hardening resin as a middle cladding layer 13. Thus, with the flat-surface glass substrate of an up-and-down cladding layer, it has the core 15 which consists of transparence resin, and structure which puts the middle cladding layer 13 firmly. For this reason, it turned out that form status change-ization hardly arises by the temperature change of a perimeter environment. Therefore, it can be said that this optical waveguide substrate is equipped with sufficient practicality.

[0028] (Gestalt 2 of operation) The structure and its manufacture approach of the optical waveguide components in the gestalt 2 of the operation of this invention to a degree are explained using drawing 5 and drawing 6 . Optical waveguide components are components which combine the optical waveguide substrate which restrains a light beam by incore and is made to spread in accordance with the shaft of a core, and an optical fiber. A press die (not shown) is first manufactured using a cemented carbide material. A press side which unifies the fixed slot of the shape of V character which fixes an optical fiber, and the flat-surface section (optical plane of composition) for forming an optical waveguide substrate is required for a press die. for this reason, two or more lines for forming a fixed slot -- a crest type projection and a line -- it is processed into a ****** material so that the flat-surface section which adjoined the crest type projection may be formed in coincidence. the example based on the gestalt of this operation -- a dimension -- 10mm in thickness, and 10mm by 5mm -- carrying out -- a line -- four spacing of a crest type projection was formed by 250 micrometers. The precious alloy film was formed as a protective coat for mold release to the press side of this press die.

[0029] Next, as shown in drawing 5 (a), it fixes so that the glass substrate 50 for [fabricated] may be located under the press die (not shown) which prepared and mentioned above the glass substrate 50 (for example, refractive-index n1=1.5,mm [in 7/K, and thickness / 2], 10mm by [coefficient-of-thermal-expansion 70x10-] 5mm) for [fabricated] for base substrates. Next, the glass substrate 50 for [fabricated] and a press die are heated, heating softening of the glass substrate 50 for [fabricated] is carried out at 700 degrees C, and press forming is performed. Consequently, as shown in drawing 5 (b), the fixed slot 51 of the shape of V character for fixing an optical fiber is formed as an optical fiber joint, and the base substrate 53 united with the flat-surface section 52 used as the optical plane of composition of a lower cladding layer is formed.
[0030] next, the line which is equivalent to a core part beforehand — the mold (not shown) which penetrates the ultraviolet rays which have heights is produced by the following approaches. For example, after grinding a quartz-glass substrate 5mm in thickness, and 5mm wide [5mm long and] at a flat surface, the pattern of a core part is formed by the patterning method using the usual photoresist. and the location which is the front face of a quartz-glass substrate and is equivalent to a core using the dry etching method — a line -- four heights (cross-section configuration; projection with a height [of 8 micrometers] x width of face of 8 micrometers) are formed at intervals of 250 micrometers.
[0031] Next, as shown in drawing 5 (b) and (c), the ultraviolet-rays hardening resin 54 of a refractive index n2 (n2=n1) is applied to the flat-surface section 52 of the base substrate 53 by spin coating. And a release agent is applied to the front face of the mold which penetrates ultraviolet rays, and it installs in the black light 20 used for the hardening process of the ultraviolet-rays hardening resin shown in drawing 2 . this time — the center line of the fixed slot 51, and a line — the mold 21 which penetrates ultraviolet rays is fixed using a guide so that the center line of heights may be in agreement. In this condition, it installs between the upper block 23 and the bottom block 22, the upper block 23 is dropped gradually, and a pressure is applied and pressed. the line of the mold 21 as shown in drawing 2 — a press is continued until the tip of heights 21a touches the front face of the part used as the lower cladding layer 59 in the base substrate 53, as shown in drawing 5 (d).
[0032] And the light source 24 of the ultraviolet rays built in the upper block 23 is turned on from the rear face of a mold in the condition as it is, ultraviolet rays are irradiated, ultraviolet-rays hardening resin 54 is stiffened, and a mold 21 is made to release from mold. As shown in drawing 5 (d) as a result, the middle cladding layer 55 which has slot 55a equivalent to a core part by the same thickness as a core is formed in the top face of the lower cladding layer 59.
[0033] Then, to formed slot 55a, as shown in drawing 6 (e), rather than ultraviolet-rays hardening resin 54, a refractive index embeds the transparence resin of the epoxy which has the refractive index n3 high about 0.3%, and forms a core 56. Furthermore, from the upper part, as shown in drawing 6 (f), the flat-surface glass substrate of a refractive index n4 (n4=n1) is made into the condition of having coalesced the optical fiber joint and the optical waveguide substrate, as an up cladding layer 57 at lamination and the base substrate 53. Thus, the optical waveguide components which have an optical fiber joint, and the lower cladding layer 59, the middle cladding layer 55, a core 56 and the optical waveguide substrate that consists of an up cladding layer 57 were produced.
[0034] With the optical waveguide components produced by the manufacture approach of the gestalt this operation, it dissociated mutually through the core 56 and the band-like middle cladding layer 55 has pasted the lower cladding layer 59 firmly further. For this reason, the pattern gap by the differential shrinkage of the mold and the middle cladding layer 55 which penetrate ultraviolet rays, and the ingredient of a core 56 becomes very small, and can imprint the configuration of the mold which penetrates ultraviolet rays good as it is. And since alignment of the fixed slot 51 of the shape of V character for fixing an optical fiber is carried out to the core and high degree of accuracy of an optical waveguide substrate, it can build optical waveguide components into a splitter etc. easily only by arranging an optical fiber in a fixed slot.
[0035] (Gestalt 3 of operation) The structure and its manufacture approach of the optical waveguide substrate in the gestalt 3 of the operation of this invention to a degree are explained using drawing 7 - drawing 10 . Drawing 7 is process drawing showing the manufacture approach of an optical waveguide substrate. As shown in drawing 7 (a), the lower cladding layer 71 which consists of a flat-surface glass substrate of a refractive index n1 is prepared. Next, as shown in drawing 7 (b), the ultraviolet-rays hardening resin 72 of a refractive index n2 (n2> n1) is applied to the optical plane of composition of the lower cladding layer 71 by spin coating.
[0036] the location which is equivalent to a core part on the other hand -- a line — the mold (not shown) which penetrates the ultraviolet rays in which the crevice was formed is prepared, ultraviolet-rays hardening resin 72 is pressed with a mold, from the rear face of a mold, ultraviolet rays are irradiated, ultraviolet-rays hardening resin is stiffened, and two or more mutually-independent bottom band-like cores 73 are formed like drawing 7 (c). Next, as shown in drawing 7 (d), the up cladding layer 74 is formed by applying the resin which has a refractive index n3 (n3<n2) so that the part of a core 73 may be wrapped in. And as shown in drawing 7 (e), the optical waveguide substrate of structure is obtained by joining the flat-surface glass substrate 75 for protection on the up cladding layer 74.
[0037] In the manufacture approach of the gestalt this operation, drawing 8 is the sectional view showing the structure of the black light 80 used for the hardening process of ultraviolet-rays hardening resin, and shows the condition before hardening. This black light 80 has the upper block 81 which can move up and down, and the block 82 under immobilization like the black light of the gestalt 1 of operation, and the light source 84 which generates ultraviolet rays is built in the upper block 81.
[0038] the location where the mold 83 which penetrates ultraviolet rays is equivalent to a core part -- a line — it has crevice 83a. this line — in the example, after crevice 83a ground the quartz-glass substrate 5mm in thickness, and 5mm wide [5mm long and] at the flat surface, it was formed by the patterning method using the usual photoresist. moreover, the dry etching method after forming a band-like pattern to a quartz-glass substrate -- using -- a quartz-glass substrate front face -- a line — four crevice 83a (cross-section configuration; projection with a depth [of 8 micrometers] x width of face of 8 micrometers) was prepared at intervals of 250 micrometers.
[0039] Next, the flat-surface glass substrate (refractive-index n1=1.5, coefficient-of-thermal-expansion 70x10-7/K, heat-resistant temperature of 700 degrees C) ground at the flat surface 2mm in thickness and 5mm wide [5mm long and] was prepared as a lower cladding layer 71, and was laid in the bottom block 82. And the refractive index applied to the top face of a flat-surface glass substrate the ultraviolet-rays hardening resin 72 which has the refractive index n2 higher about 0.3% than n1 by spin coating. Then, the mold 83 made from quartz glass mentioned above was put on the top face of ultraviolet-rays hardening resin 72. Drawing 8 shows this condition.
[0040] Next, the upper block 81 was dropped gradually, and the pressure was applied and pressed. Continued press until the tip of the mold 83 made from quartz glass touched the front face of the flat-surface glass substrate which forms the lower cladding layer 71, as shown in drawing 9 , and the light source of ultraviolet rays was made to turn on, and ultraviolet rays were irradiated from the rear face of a mold 83. The mold 83 was released from mold in the place which ultraviolet-rays hardening resin 72

hardened. As shown in drawing 7 (c) in this condition, four cores 73 were formed on the lower cladding layer 71. In the example, each core 73 was separated at intervals of 250 micrometers, and the lower cladding layer 71 was pasted further firmly. For this reason, the pattern gap with the mold 83 and core materials which penetrate ultraviolet rays was able to become very small, and was able to imprint the configuration of a mold 83 good as it was.
[0041] Then, the epoxy resin which has the same refractive index as the lower cladding layer 71 was applied so that a core 73 might be wrapped in, and it considered as the up cladding layer 74, and the optical waveguide substrate as shows the flat-surface glass substrate 75 for protection further to lamination and drawing 10 from the upper part was produced.
[0042] This optical waveguide substrate makes resin the up cladding layer 74, makes a flat-surface glass substrate the lower cladding layer 71, uses ultraviolet-rays hardening resin as a core 73, and has further structure equipped with the flat-surface glass substrate 75 for protection on the up cladding layer 74. Thus, since the up cladding layer 74 which consists of an epoxy resin was firmly put with the up-and-down flat-surface glass substrate, it turned out that form status change-ization by the temperature change of a perimeter environment is hardly produced. Therefore, it can be said that this optical waveguide substrate is equipped with sufficient practicality.
[0043] (Gestalt 4 of operation) The structure and its manufacture approach of the optical waveguide components in the gestalt 4 of the operation of this invention to a degree are explained using drawing 11 and drawing 12 . First, a press die (not shown) is manufactured using a cemented carbide material. A press side must be formed in a press die so that the fixed slot of the shape of V character for fixing an optical fiber and the flat-surface section for forming an optical waveguide substrate may be unified. as a mold [as opposed to / the press die prepared in the example processes it into a cemented carbide material, and / a fixed V character-like slot] -- a line -- the-two or more crest type projection was formed, and the flat-surface section was formed further horizontally [the]. that in which the appearance of a press die has 10mm in thickness, and a 10mm long and 5mm wide dimension -- carrying out -- a line -- four spacing of a crest type projection was formed by 250 micrometers. The precious alloy film was formed as a protective coat for mold release to the press side of this press die.
[0044] Next, as shown in drawing 11 (a), the glass substrate 110 (refractive-index n1=1.5,mm [in 7/K, and thickness / 2], 10mm by [coefficient-of-thermal-expansion 70x10-] 5mm) for [fabricated] was prepared, and was fixed under the press die mentioned above. And the press die was heated, heating softening of the glass substrate 110 for [fabricated] was carried out at 750 degrees C, and press forming was performed. Consequently, as shown in drawing 11 (b), the base substrate 113 with which the fixed slot 111 of the shape of V character for fixing an optical fiber and the flat-surface section 112 for forming an optical waveguide substrate were unified was formed.
[0045] next, the location which is equivalent to a core part beforehand -- a line -- the mold (not shown) which penetrates the ultraviolet rays which have a crevice was produced by the following approaches. After grinding the substrate of quartz glass 5mm in thickness, and 5mm wide [5mm long and] at a flat surface, the pattern used as a core partial fang furrow was formed by the patterning method using the usual photoresist. and the location which is the front face of a quartz-glass substrate and is equivalent to a core using the dry etching method -- a line -- four crevices (cross-section configuration; projection with a depth [of 8 micrometers] x width of face of 8 micrometers) were formed at intervals of 250 micrometers.
[0046] Next, as shown in drawing 11 (b) and (c), the ultraviolet-rays hardening resin 114 of the refractive index n2 higher about 0.3% than n1 was applied by spin coating on the flat-surface section 112 (optical plane of composition) of the base substrate 113. and a line -- the release agent was applied to the front face of the mold which penetrates the ultraviolet rays which have a crevice, and it set in the black light 80 shown in drawing 8 . At this time, the mold which penetrates ultraviolet rays so that the center line of the fixed slot 111 and the center line of a slot may be in agreement was fixed using the guide. In this condition, it laid in the top face of the bottom block 82, the upper block 81 was dropped gradually, and the pressure was applied and pressed. Press was continued until the apical surface of the mold 83 made from quartz glass shown in drawing 8 touched the front face of the part of the lower cladding layer 116 of the base substrate 113 shown in drawing 11 (d).
[0047] And in the condition as it is, the light source 84 of ultraviolet rays was made to turn on, from the rear face of the mold 83 made from quartz glass, ultraviolet rays were irradiated, ultraviolet-rays hardening resin 114 was stiffened, the core 115 was formed, and the mold 83 was released from mold. Consequently, as shown in drawing 11 (d), four cores 115 were formed in the optical plane of composition of the lower cladding layer 116.
[0048] To the whole substrate taken out succeedingly, as shown in drawing 12 (e), the resin of the epoxy of the same refractive index n3 as the lower cladding layer 116 was applied so that a core 115 might be wrapped in, and the up cladding layer 117 was formed. Furthermore, the optical waveguide components which have the optical waveguide substrate which serves as an optical fiber joint from the lower cladding layer 116, a core 115, and the up cladding layer 117 in the flat-surface glass substrate 118 for protection as shown in lamination and drawing 12 (f) from the upper part were produced.
[0049] Four cores 115 were separated mutually and the optical waveguide components produced by the manufacture approach of the gestalt this operation are further pasted up on the lower cladding layer 116 firmly, as shown in drawing 12 (f). For this reason, the pattern gap with the mold and core materials which penetrate ultraviolet rays becomes very small, and can imprint the configuration of the mold which penetrates ultraviolet rays good as it is. And alignment of the fixed slot 111 of the shape of V character for fixing an optical fiber is carried out to the core of an optical waveguide substrate with high precision. For this reason, optical waveguide components are easily incorporable into a splitter etc. only by arranging an optical fiber in the fixed slot 111.
[0050]
[Effect of the Invention] According to this invention, between the mold which penetrates ultraviolet rays, and ultraviolet-rays hardening resin, since the pattern gap by the contraction generated at the hardening process of the ultraviolet-rays hardening resin by UV irradiation can be made remarkably small, formation of an efficient core pattern with a high precision is attained. Therefore, a cheap optical waveguide substrate and optical waveguide components can be manufactured efficiently. Moreover, form status change-ization of as opposed to change of ambient temperature in the optical waveguide substrate and optical waveguide components of this invention becomes small, and what has very high dependability is obtained.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] The sectional view showing the outline process of the manufacture approach of the optical waveguide substrate in the gestalt 1 of operation of this invention
[Drawing 2] The outline sectional view showing the condition of having set the mold which penetrates ultraviolet rays in the black light used for manufacture of the optical waveguide substrate of the gestalt 1 of operation
[Drawing 3] The outline sectional view showing the condition that it was used for manufacture of the optical waveguide substrate of the gestalt 1 of operation, and the hardening process of ultraviolet-rays hardening resin was completed in the black light
[Drawing 4] The cross-section block diagram of the optical waveguide substrate manufactured by the manufacture approach of the gestalt 1 operation
[Drawing 5] The perspective view showing the outline process (the 1) of the manufacture approach of the optical waveguide components in the gestalt 2 of operation of this invention
[Drawing 6] The perspective view showing the outline process (the 2) of the manufacture approach of the optical waveguide components in the gestalt 2 of operation
[Drawing 7] The sectional view showing the outline process of the manufacture approach of the optical waveguide substrate in the gestalt 3 of operation of this invention
[Drawing 8] The outline sectional view showing the condition of having set the mold which penetrates ultraviolet rays in the black light used for manufacture of the optical waveguide substrate of the gestalt 3 of operation
[Drawing 9] The outline sectional view showing the condition that the hardening process of ultraviolet-rays hardening resin was completed, in the black light used for manufacture of the optical waveguide substrate of the gestalt 3 of operation
[Drawing 10] The cross-section block diagram of the optical waveguide substrate in the gestalt 3 of operation
[Drawing 11] The perspective view showing the outline process (the 1) of the manufacture approach of the optical waveguide components in the gestalt 4 of operation of this invention
[Drawing 12] The perspective view showing the outline process (the 2) of the manufacture approach of the optical waveguide components in the gestalt 4 of operation
[Drawing 13] The cross-section block diagram of the conventional common optical waveguide substrate
[Drawing 14] The sectional view showing the outline process of the manufacture approach of the conventional common optical waveguide substrate
[Drawing 15] The sectional view showing the outline process of the manufacture approach of the optical waveguide substrate by the conventional press forming
[Description of Notations]
11, 59, 71,116 Lower cladding layer
12, 54, 72,114 Ultraviolet-rays hardening resin
13 55 Middle cladding layer
14 55a Slot
15, 56, 73,115 Core
16, 57, 74,117 Up cladding layer
20 80 Black light
21 83 Mold which penetrates ultraviolet rays
21a a line — heights
22 82 Bottom block
23 81 Top block
50,110 Glass substrate for [fabricated]
51,111 Fixed slot
52,112 Flat-surface section
53,113 Base substrate
75,118 Flat-surface glass substrate for protection
83a a line — a crevice

[Translation done.]

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(71)出願人　000005821
松下電器産業株式会社
大阪府門真市大字門真1006番地
(72)発明者　梅谷　誠
大阪府門真市大字門真1006番地　松下電器産業株式会社内
(72)発明者　是永　継博
大阪府門真市大字門真1006番地　松下電器産業株式会社内
(74)代理人　100095555
弁理士　池内　寛幸　（外5名）

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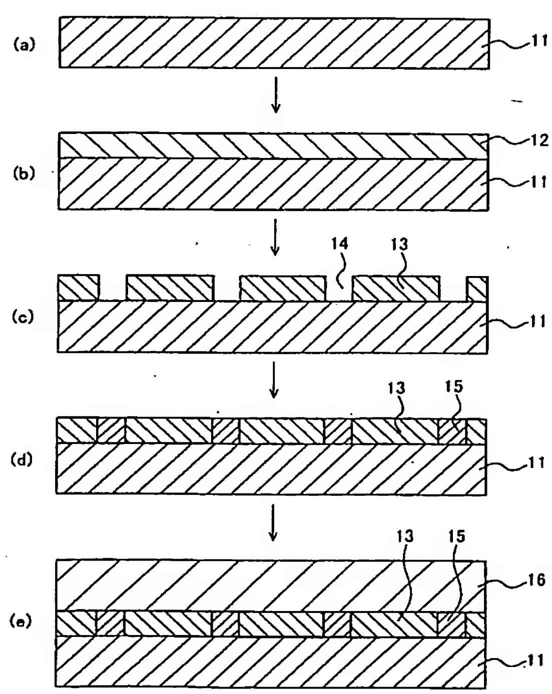
(54)【発明の名称】　光導波路基板とその製造方法、及び光導波路部品とその製造方法

(57)【要約】
【課題】　コア成形時に熱膨張に起因する転写精度の低下を生じることのない、微細パターンのコアを有する光導波路基板の構成及び製造方法を提供する。
【解決手段】　平面ガラス基板からなる下部クラッド層11上に、紫外線硬化樹脂12を塗布する。コア形状の線状凸部を有する紫外線を透過する型の裏面より紫外線を照射し、紫外線硬化樹脂12を硬化させ、溝部14を有する中間クラッド層13を形成する。次に屈折率の異なる透明樹脂を溝部14に充填し、コア15を形成する。そして、その上に平面ガラス基板からなる上部クラッド層17を固定し、光導波路基板を製作する。



【特許請求の範囲】

【請求項１】　光ビームをコア内で拘束して前記コアの軸に沿って伝搬させる光導波路基板の製造方法であって、

屈折率ｎ１のガラス基板を所定形状に加工して、一方の平面を光学的接合面とする下部クラッド層を得る工程と、

前記下部クラッド層の光学的接合面に、屈折率ｎ２を有する紫外線硬化樹脂を塗布する工程と、

前記コアと同一形状を有する線状凸部が形成された紫外線を透過する型を用いて前記紫外線硬化樹脂を押圧し、前記型の線状凸部を前記下部クラッド層の光学的接合面に当接させる工程と、

前記型の裏面より紫外線を照射することにより、前記紫外線硬化樹脂を硬化させた後、前記型を離型し、前記コアの空間となる溝部が形成された中間クラッド層を得る工程と、

前記中間クラッド層の前記溝部に、屈折率ｎ３（ｎ３＞ｎ２，ｎ１）を有する透明樹脂を充填して、硬化させることにより前記コアを得る工程と、

前記コアが形成された後の前記中間クラッド層の上面に、屈折率ｎ４（ｎ４＜ｎ３）を有する平面ガラス基板を接合することにより上部クラシド層を形成する工程とを有することを特徴とする光導波路基板の製造方法。

【請求項２】　光ビームをコア内で拘束して前記コアの軸に沿って伝搬させる光導波路基板であって、

屈折率ｎ１の平面ガラス基板からなる下部クラッド層と、

屈折率ｎ４の平面ガラス基板からなる上部クラッド層と、

前記下部クラッド層と前記上部クラッド層とに挟持され、屈折率ｎ２を有する紫外線硬化樹脂からなり、前記コアの空間となる溝部が設けられた中間クラッド層と、

前記中間クラッド層の溝部に、屈折率ｎ３（ｎ３＞ｎ４，ｎ２，ｎ１）を有する透明樹脂を充填し硬化させて得た前記コアとを有することを特徴とする光導波路基板。

【請求項３】　光ビームをコア内で拘束して前記コアの軸に沿って伝搬させる光導波路基板と光ファイバとを結合させる光導波路部品の製造方法であって、

屈折率ｎ１のガラス基板を所定形状に加工して、一方の平面を光学的接合面とする被成形用ガラス基板を得る工程と、

前記光ファイバの固定溝を形成するための線状山型突起が形成されたプレス型を用いて前記被成形用ガラス基板を押圧するとともに、前記被成形用ガラス基板を加熱することにより軟化させ、前記被成形用ガラス基板の一部に前記固定溝を形成するとともに、前記被成形用ガラス基板の他の部分に下部クラッド層を形成する工程と、

前記被成形用ガラス基板の下部クラッド層の上面に、屈折率ｎ２を有する紫外線硬化樹脂を塗布する工程と、

前記コアと同一形状を有する線状凸部が形成された紫外線を透過する型を用いて、前記線状凸部と前記光ファイバの固定溝の中心線が一致するように前記紫外線硬化樹脂を押圧し、前記型の線状凸部を前記被成形用ガラス基板の下部クラッド層の平面部分に当接させる工程と、

前記型の裏面より紫外線を照射することにより前記紫外線硬化樹脂を硬化させた後、前記型を開放し、前記コアの空間となる溝部が形成された中間クラッド層を得る工程と、

前記中間クラッド層の溝部に、屈折率ｎ３（ｎ３＞ｎ２，ｎ１）を有する透明樹脂を充填して硬化させることにより前記コアを得る工程と、

前記コアが形成された後の中間クラッド層の上面に、屈折率ｎ４（ｎ４＜ｎ３）を有する平面ガラス基板を接合することにより上部クラッド層を形成する工程とを有することを特徴とする光導波路部品の製造方法。

【請求項４】　光ビームをコア内で拘束して前記コアの軸に沿って伝搬させる光導波路基板と光ファイバとを結合させる光導波路部品であって、

屈折率ｎ１のガラス基板からなり、前記ガラス基板の一部に光学的接合面が形成された下部クラッド層、及び前記ガラス基板の他の部分に前記光ファイバの固定溝が形成された光ファイバ接合部を有するベース基板と、

前記ベース基板の下部クラッド層の光学的接合面に設けられ、屈折率ｎ２を有する紫外線硬化樹脂からなり、前記コアの空間となる溝部が前記光ファイバの固定溝の延長線上に設けられた中間クラッド層と、

前記中間クラッド層の溝部に、屈折率ｎ３（ｎ３＞ｎ２，ｎ１）を有する透明樹脂を充填し硬化させて得た前記コアと、

前記コアと中間クラッド層の上面に、屈折率ｎ４（ｎ４＜ｎ３）を有する平面ガラス基板を接合して形成された上部クラッド層とを有することを特徴とする光導波路部品。

【請求項５】　光ビームをコア内で拘束して前記コアの軸に沿って伝搬させる光導波路基板の製造方法であって、

屈折率ｎ１のガラス基板を所定形状に加工して、一方の平面を光学的接合面とする下部クラッド層を得る工程と、

前記下部クラッド層の光学的接合面に、屈折率ｎ２（ｎ２＞ｎ１）を有する紫外線硬化樹脂を塗布する工程と、

前記コアと同一形状を有する線状凹部を形成した紫外線を透過する型を用いて前記紫外線硬化樹脂を押圧し、前記型の線状凹部を除く平面部を前記下部クラッド層の光学的接合面に当接させる工程と、

前記型の裏面より紫外線を照射することにより前記紫外線硬化樹脂を硬化させ、押圧状態から前記型を開放することにより、前記下部クラッド層の上面に前記コアを形

成する工程と、
前記コアを包み込むように屈折率ｎ３（ｎ３＜ｎ２）を有する透明樹脂を塗布し、硬化させることにより、平板状の上部クラッド層を形成する工程と、
前記上部クラッド層の上面に保護用平面ガラス基板を形成する工程とを有することを特徴とする光導波路基板の製造方法。
【請求項６】　光ビームをコア内で拘束して前記コアの軸に沿って伝搬させる光導波路基板であって、
屈折率ｎ１の平面ガラス基板からなる下部クラッド層と、
前記下部クラッド層の上面に、屈折率ｎ２（ｎ２＞ｎ１）を有する紫外線硬化樹脂を用いて凸状に形成された前記コアと、
前記コアを包み込むように屈折率ｎ３（ｎ３＜ｎ２）を有する透明樹脂を塗布し硬化させることにより平板状に形成された上部クラッド層と、
前記上部クラッド層の上面に形成された保護用平面ガラス基板とを有することを特徴とする光導波路基板。
【請求項７】　光ビームをコア内で拘束して前記コアの軸に沿って伝搬させる光導波路基板と光ファイバとを結合させる光導波路部品の製造方法であって、
屈折率ｎ１のガラス基板を所定形状に加工して、一方の平面を光学的接合面とする被成形用ガラス基板を得る工程と、
前記光ファイバの固定溝を形成するための線状山型突起が形成されたプレス型を用いて前記被成形用ガラス基板を押圧するとともに、前記被成形用ガラス基板を加熱することにより軟化させ、前記被成形用ガラス基板の一部に前記光ファイバの固定溝を形成すると共に、前記被成形用ガラス基板の他の部分に下部クラッド層を形成する工程と、
前記被成形用ガラス基板の下部クラッド層の上面に、屈折率ｎ２（ｎ２＞ｎ１）を有する紫外線硬化樹脂を塗布する工程と、
前記コアと同一形状を有する線状凹部を形成した紫外線を透過する型を用いて、前記線状凹部と前記光ファイバの固定溝の中心線が一致するように前記紫外線硬化樹脂を押圧し、前記型の凹部を除く平面部を前記下部クラッド層の上面に当接させる工程と、
前記型の裏面より紫外線を照射することにより前記紫外線硬化樹脂を硬化させ、押圧状態から前記型を開放することにより、前記下部クラッド層の上面に前記コアを形成する工程と、
前記コアを包み込むように屈折率ｎ３（ｎ３＜ｎ２）を有する透明樹脂を塗布することにより、平板状の上部クラッド層を形成する工程と、
前記上部クラッド層の上面に保護用平面ガラス基板を形成する工程とを有することを特徴とする光導波路部品の製造方法。
【請求項８】　光ビームをコア内で拘束して前記コアの軸に沿って伝搬させる光導波路基板と光ファイバとを結合させる光導波路部品であって、
屈折率ｎ１のガラス基板からなり、前記ガラス基板の一部に光学的接合面が形成された下部クラッド層、及び前記ガラス基板の他の部分に前記光ファイバの固定溝が形成された光ファイバ接合部を有するベース基板と、
前記ベース基板の下部クラッド層の上面に設けられ、屈折率ｎ２（ｎ２＞ｎ１）を有する紫外線硬化樹脂からなり、前記光ファイバの固定溝の延長線と一致するよう凸状に形成された前記コアと、
前記コアを包み込むように屈折率ｎ３（ｎ３＜ｎ２）を有する樹脂を塗布し硬化させることにより、平板状に形成された上部クラッド層と、
前記上部クラッド層の上面にガラス基板を接合することにより形成された保護用平面ガラス基板とを有することを特徴とする光導波路部品。
【発明の詳細な説明】
【０００１】
【発明の属する技術分野】本発明は、安価な方法で製造できる高精度で信頼性の高い光導波路基板とその製造方法、及び光ファイバを接続するための光導波路部品とその製造方法に関する。
【０００２】
【従来の技術】図１３は、一般的な石英系シングルモードの光導波路基板の構造を示す断面図である。この光導波路基板は、下部クラッド層１２１及び上部クラッド層１２３よりも屈折率の高いコア１２２ａの部分に光ビームが案内されて、光ビームが光導波路の軸方向に伝搬する構成となっている。
【０００３】このような従来の光導波路基板の製造方法を、図１４を用いて説明する。図１４（ａ）に示すように、下部クラッド層１２１を兼ねた石英基板上に、火炎堆積法などを用いて、下部クラッド層１２１よりも屈折率の高い光学材料１２２を成膜し、図１４（ｂ）のような状態にする。次にフォトリソグラフ法並びにドライエッチング法により、光学材料１２２を所定のコアのパターンに加工し、図１４（ｃ）のようにコア１２２ａを形成する。最後に図１４（ｄ）に示すように、コア１２２ａを覆うよう上部クラッド層１２３を形成して、光導波路基板に仕上げる。このような製造方法を記載した参考文献としては、河内著、オプトロニクス、Ｎｏ．８、８５、１９８８等がある。
【０００４】一方、樹脂材料は、石英に比べて光の透過性能や信頼性が劣るが、成形が容易である。このため光導波路基板の低コスト化を図るべく、樹脂を用いた光導波路基板も検討されている。樹脂製の光導波路基板の製造方法は、クラッド層及びコア層を順次形成し、石英製の光導波路基板の製造と同様に、コアをドライエッチング法によりパターニングして製造する。

【０００５】しかしながら、コアのパターニングにフォトリソグラフ法及びドライエッチング法を用いた場合、複雑で高精度な設備が多数必要となる。従って、このような方法で光導波路基板を製造していたのでは、材料は安価であるが、実質的に光導波路基板を安価に製造することが困難である。

【０００６】最近では、特開平８－３２０４２０号公報に開示されているように、図１５に示したような光導波路基板の製造方法が用いられている。この製造方法では、図１５（ａ）に示すように、ガラスのような熱可塑性材料からなる被成形物１３１を用い、これを加熱軟化させて平板状にする。次に図１５（ｂ）に示すように、コアパターンの反転形状（凸部）を有するプレス型でプレス成形し、冷却後に成形物を取り出す。こうするとコアパターンの転写が行われ、凹部１３１ａが形成される。この平板状部材を光導波路基板にするには、図１５（ｃ）に示すように、屈折率の異なる樹脂１３２を凹部１３１ａに埋め込む。次に図１５（ｄ）に示すように、上部クラッド層１３３となる基板を下部クラッド層１３４の上面に形成して光導波路基板を作製する。

【０００７】

【発明が解決しようとする課題】しかしながら、このような転写方法では、加熱軟化した被成形物をプレス型と接触させて冷却するので、被成形物とプレス型との熱膨張係数の差に起因して熱応力が発生する。その結果、被成形物に転写されるパターンの精度が低下する。特に、プレス型の中心から外周に向けて距離が長くなるほど、パターンずれが大きくなる。特に、被成形物に樹脂材料を用いた場合は、型の材料として用いられる石英などの材料と比べると、１～２桁程度も熱膨張係数が大きいので、ひどい場合には、プレス型で樹脂材料がえぐられるようになる。

【０００８】実際、本発明者が具体的に検討したところによると、プレス型を用いて樹脂基板に転写すると、ミクロンオーダのレベルで溝の幅が広がり、溝形状が乱れてしまった。この現象は、冷却時に樹脂基板がプレス型よりも大きく収縮し、樹脂基板がその転写中央部に向かって収縮した結果であると考えられる。このように、樹脂材料は低温で成形できる長所があり、製造コスト上も有利であるにもかかわらず、プレス成形によりパターンを転写しようとすると、微細なパターンを正確に転写できなくなるという問題があった。

【０００９】また、光導波路基板全体を樹脂で構成した場合、熱膨張係数が大きいために、周囲の温度変化により光導波路パターンが変形し、信頼性が十分確保されなくなるという課題があった。

【００１０】本発明は、このような従来の問題点に鑑みてなされたものであって、従来の熱間による成形法を用いることなく、紫外線硬化樹脂を中間クラッド層あるいはコアに用いて、熱膨張に起因する転写精度の低下を防止し、微細パターンのコアを有する光導波路基板、光ファイバを接続するための光導波路部品、及びそれらの製造方法を実現することを目的とする。

【００１１】

【課題を解決するための手段】本発明の光導波路基板は、光ビームをコア内で拘束して前記コアの軸に沿って伝搬させる光導波路基板である。また本発明の光導波路部品は、光ビームをコア内で拘束して前記コアの軸に沿って伝搬させる光導波路基板と光ファイバとを結合させる光導波路部品である。本発明の製造方法は、それらの光導波路基板あるいは光導波路部品を製造する方法である。

【００１２】本発明の第１の光導波路基板の製造方法は、屈折率ｎ１のガラス基板を所定形状に加工して、一方の平面を光学的接合面とする下部クラッド層を得る工程と、前記下部クラッド層の光学的接合面に、屈折率ｎ２を有する紫外線硬化樹脂を塗布する工程と、前記コアと同一形状を有する線状凸部が形成された紫外線を透過する型を用いて前記紫外線硬化樹脂を押圧し、前記型の線状凸部を前記下部クラッド層の光学的接合面に当接させる工程と、前記型の裏面より紫外線を照射することにより、前記紫外線硬化樹脂を硬化させた後、前記型を離型し、前記コアの空間となる溝部が形成された中間クラッド層を得る工程と、前記中間クラッド層の前記溝部に、屈折率ｎ３（ｎ３＞ｎ２，ｎ１）を有する透明樹脂を充填して、硬化させることにより前記コアを得る工程と、前記コアが形成された後の前記中間クラッド層の上面に、屈折率ｎ４（ｎ４＜ｎ３）を有する平面ガラス基板を接合することにより上部クラッド層を形成する工程とを有する。

【００１３】本発明の第１の光導波路基板は、屈折率ｎ１の平面ガラス基板からなる下部クラッド層と、屈折率ｎ４の平面ガラス基板からなる上部クラッド層と、前記下部クラッド層と前記上部クラッド層とに挟持され、屈折率ｎ２を有する紫外線硬化樹脂からなり、前記コアの空間となる溝部が設けられた中間クラッド層と、前記中間クラッド層の溝部に、屈折率ｎ３（ｎ３＞ｎ４，ｎ２，ｎ１）を有する透明樹脂を充填し硬化させて得た前記コアとを有する。

【００１４】本発明の第１の光導波路部品の製造方法は、屈折率ｎ１のガラス基板を所定形状に加工して、一方の平面を光学的接合面とする被成形用ガラス基板を得る工程と、前記光ファイバの固定溝を形成するための線状山型突起が形成されたプレス型を用いて前記被成形用ガラス基板を押圧するとともに、前記被成形用ガラス基板を加熱することにより軟化させ、前記被成形用ガラス基板の一部に前記固定溝を形成するとともに、前記被成形用ガラス基板の他の部分に下部クラッド層を形成する工程と、前記被成形用ガラス基板の下部クラッド層の上面に、屈折率ｎ２を有する紫外線硬化樹脂を塗布する工

程と、前記コアと同一形状を有する線状凸部が形成された紫外線を透過する型を用いて、前記線状凸部と前記光ファイバの固定溝の中心線が一致するように前記紫外線硬化樹脂を押圧し、前記型の線状凸部を前記被成形用ガラス基板の下部クラッド層の平面部分に当接させる工程と、前記型の裏面より紫外線を照射することにより前記紫外線硬化樹脂を硬化させた後、前記型を開放し、前記コアの空間となる溝部が形成された中間クラッド層を得る工程と、前記中間クラッド層の溝部に、屈折率ｎ３（ｎ３＞ｎ２，ｎ１）を有する透明樹脂を充填して硬化させることにより前記コアを得る工程と、前記コアが形成された後の中間クラッド層の上面に、屈折率ｎ４（ｎ４＜ｎ３）を有する平面ガラス基板を接合することにより上部クラッド層を形成する工程とを有する。

【００１５】本発明の第１の光導波路部品は、屈折率ｎ１のガラス基板からなり、前記ガラス基板の一部に光学的接合面が形成された下部クラッド層、及び前記ガラス基板の他の部分に前記光ファイバの固定溝が形成された光ファイバ接合部を有するベース基板と、前記ベース基板の下部クラッド層の光学的接合面に設けられ、屈折率ｎ２を有する紫外線硬化樹脂からなり、前記コアの空間となる溝部が前記光ファイバの固定溝の延長線上に設けられた中間クラッド層と、前記中間クラッド層の溝部に、屈折率ｎ３（ｎ３＞ｎ２，ｎ１）を有する透明樹脂を充填し硬化させて得た前記コアと、前記コアと中間クラッド層の上面に、屈折率ｎ４（ｎ４＜ｎ３）を有する平面ガラス基板を接合して形成された上部クラッド層とを有する。

【００１６】本発明の第２の光導波路基板の製造方法は、屈折率ｎ１のガラス基板を所定形状に加工して、一方の平面を光学的接合面とする下部クラッド層を得る工程と、前記下部クラッド層の光学的接合面に、屈折率ｎ２（ｎ２＞ｎ１）を有する紫外線硬化樹脂を塗布する工程と、前記コアと同一形状を有する線状凹部を形成した紫外線を透過する型を用いて前記紫外線硬化樹脂を押圧し、前記型の線状凹部を除く平面部を前記下部クラッド層の光学的接合面に当接させる工程と、前記型の裏面より紫外線を照射することにより前記紫外線硬化樹脂を硬化させ、押圧状態から前記型を開放することにより、前記下部クラッド層の上面に前記コアを形成する工程と、前記コアを包み込むように屈折率ｎ３（ｎ３＜ｎ２）を有する透明樹脂を塗布し硬化させることにより、平板状の上部クラッド層を形成する工程と、前記上部クラッド層の上面に保護用平面ガラス基板を形成する工程とを有する。

【００１７】本発明の第２の光導波路基板は、屈折率ｎ１の平面ガラス基板からなる下部クラッド層と、前記下部クラッド層の上面に、屈折率ｎ２（ｎ２＞ｎ１）を有する紫外線硬化樹脂を用いて凸状に形成された前記コアと、前記コアを包み込むように屈折率ｎ３（ｎ３＜ｎ２）を有する透明樹脂を塗布し硬化させることにより平板状に形成された上部クラッド層と、前記上部クラッド層の上面に形成された保護用平面ガラス基板とを有する。

【００１８】本発明の第２の光導波路部品の製造方法は、屈折率ｎ１のガラス基板を所定形状に加工して、一方の平面を光学的接合面とする被成形用ガラス基板を得る工程と、前記光ファイバの固定溝を形成するための線状山型突起が形成されたプレス型を用いて前記被成形用ガラス基板を押圧するとともに、前記被成形用ガラス基板を加熱することにより軟化させ、前記被成形用ガラス基板の一部に前記光ファイバの固定溝を形成すると共に、前記被成形用ガラス基板の他の部分に下部クラッド層を形成する工程と、前記被成形用ガラス基板の下部クラッド層の上面に、屈折率ｎ２（ｎ２＞ｎ１）を有する紫外線硬化樹脂を塗布する工程と、前記コアと同一形状を有する線状凹部を形成した紫外線を透過する型を用いて、前記線状凹部と前記光ファイバの固定溝の中心線が一致するように前記紫外線硬化樹脂を押圧し、前記型の凹部を除く平面部を前記下部クラッド層の上面に当接させる工程と、前記型の裏面より紫外線を照射することにより前記紫外線硬化樹脂を硬化させ、押圧状態から前記型を開放することにより、前記下部クラッド層の上面に前記コアを形成する工程と、前記コアを包み込むように屈折率ｎ３（ｎ３＜ｎ２）を有する透明樹脂を塗布することにより、平板状の上部クラッド層を形成する工程と、前記上部クラッド層の上面に保護用平面ガラス基板を形成する工程とを有する。

【００１９】本発明の第２の光導波路部品は、屈折率ｎ１のガラス基板からなり、前記ガラス基板の一部に光学的接合面が形成された下部クラッド層、及び前記ガラス基板の他の部分に前記光ファイバの固定溝が形成された光ファイバ接合部を有するベース基板と、前記ベース基板の下部クラッド層の上面に設けられ、屈折率ｎ２（ｎ２＞ｎ１）を有する紫外線硬化樹脂からなり、前記光ファイバの固定溝の延長線と一致するよう凸状に形成された前記コアと、前記コアを包み込むように屈折率ｎ３（ｎ３＜ｎ２）を有する樹脂を塗布し硬化させることにより、平板状に形成された上部クラッド層と、前記上部クラッド層の上面にガラス基板を接合することにより形成された保護用平面ガラス基板とを有する。

【００２０】

【発明の実施の形態】以下、本発明の各実施の形態について図面を参照しながら説明する。

【００２１】（実施の形態１）本発明の実施の形態１における光導波路基板の構造とその製造方法について、図１～図４を用いて説明する。光導波路基板とは、光ビームをコア内で拘束してコアの軸に沿って伝搬させるものである。図１は、本実施の形態における光導波路基板の製造方法の概略工程図である。図１（ａ）に示すよう

に、屈折率ｎ１の平面ガラス基板からなる下部クラッド層１１を水平に固定し、図１（ｂ）に示すように紫外線硬化樹脂１２を、下部クラッド層１１の光学的接合面である上面に塗布する。この紫外線硬化樹脂１２は、屈折率ｎ２を有するものである。

【００２２】次に、コアに相当する位置に、線状凸部を有する紫外線を透過する型（図示せず）を予め作成しておき、その型で紫外線硬化樹脂１２を押圧し、型の裏面より紫外線を照射することにより、紫外線硬化樹脂１２を硬化させ、型を離型する。そうすると、図１（ｃ）に示すように、コアと同一厚みで、コアに相当する溝部１４を有する中間クラッド層１３が形成される。そして図１（ｄ）に示すように、溝部１４に屈折率ｎ３（ｎ３＞ｎ２，ｎ１）の透明樹脂を充填し、コア１５を形成する。その上に、図１（ｅ）に示すように、屈折率ｎ４（ｎ４＜ｎ３）を有する平面ガラス基板からなる上部クラッド層１６を設け、光導波路基板が完成する。

【００２３】図２は、本実施の形態の製造方法に於いて、紫外線硬化樹脂１２の硬化工程に用いる紫外線照射装置２０を示す断面図である。図２は、硬化前の状態を示す。紫外線を透過する型２１は、コアを形成するための線状凸部２１ａを有する石英製の型である。この線状凸部２１ａは、本実施の形態に基く実施例では、厚さ５ｍｍ、縦５ｍｍ×横５ｍｍの石英ガラス基板を平面に研磨した後、通常のフォトレジストを用いたパターニング法により形成した。実施例では、石英ガラス基板に対して帯状のパターンを形成した後、ドライエッチング法を用いて石英ガラス基板表面に、線状凸部２１ａ（断面形状；高さ８μｍ×幅８μｍの突起）を２５０μｍ間隔で４本設けた。

【００２４】一方、下部クラッド層１１として用いた平面ガラス基板は、厚さ２ｍｍ、縦５ｍｍ×横５ｍｍの平面に研磨したもので、屈折率ｎ１＝１．５、熱膨張係数７０×10^{-7}／Ｋの特性を有している。この下部クラッド層１１にｎ１と同じ屈折率ｎ２を有する紫外線硬化樹脂１２を、スピンコーティングにより均一の厚みで塗布した。続いて、前述した石英製の型２１に離型剤を塗布した後、紫外線硬化樹脂１２上に型２１を載せて、下ブロック２２上に置いた。

【００２５】この状態で、紫外線を発生する光源２４を内蔵した上ブロック２３を徐々に下降させ、圧力を加えて押圧した。図３に示すように、石英製の型２１の線状凸部２１ａの先端が、下部クラッド層１１の表面に接するまで押圧を続け、型２１の裏面より紫外線を照射し、紫外線硬化樹脂１２を硬化させた後、型２１を離型させた。このときの基板は図３に示すように、下部クラッド層１１上に、コアと同一厚みで、コアに相当する溝部を有する中間クラッド層１３が形成された。この基板では、中間クラッド層１３がコアで互いに分離されて帯状になっている。さらに帯状の中間クラッド層１３は、下

部クラッド層１１に強固に接着されているので、型２１と中間クラッド層１３とのパターンずれが非常に小さくなり、型２１の形状がそのまま良好に転写されたものとなる。

【００２６】引き続いて、図１（ｃ）、（ｄ）に示すように、形成された溝部１４に、中間クラッド層１３よりも０．３％程度高い屈折率ｎ３を有するエポキシ製の透明樹脂を埋め込み、図１（ｄ）のようにコア１５を形成した。そして更にその上部から下部クラッド層１１と同一の平面ガラス基板からなる上部クラッド層１６を貼り合わせた。このようにして、図４に示す光導波路基板を作製した。

【００２７】この光導波路基板は、エポキシ樹脂をコア１５とし、平面ガラス基板を上部クラッド層１６及び下部クラッド層１１とし、紫外線硬化樹脂を中間クラッド層１３として備えている。このように上下のクラッド層の平面ガラス基板により、透明樹脂からなるコア１５と中間クラッド層１３を強固に挟み込む構造となっている。このため、周囲環境の温度変化によって形状変化がほとんど生じないことが判った。従って、この光導波路基板は十分な実用性を備えているといえる。

【００２８】（実施の形態２）次に本発明の実施の形態２における光導波路部品の構造とその製造方法について、図５及び図６を用いて説明する。光導波路部品とは、光ビームをコア内で拘束してコアの軸に沿って伝搬させる光導波路基板と、光ファイバとを結合させる部品である。まず超硬合金素材を用いてプレス型（図示せず）を製作する。プレス型には、光ファイバを固定するＶ字状の固定溝と、光導波路基板を形成するための平面部（光学的接合面）とを一体化するようなプレス面が必要である。このため、固定溝を形成するための複数の線状山型突起と、線状山型突起に隣接した平面部とが同時に形成されるよう、硬合金素材に加工を施す。本実施の形態に基く実施例では、外形寸法が厚さ１０ｍｍ、縦１０ｍｍ×横５ｍｍとし、線状山型突起の間隔は２５０μｍで４本形成した。このプレス型のプレス面に離型用保護膜として貴金属合金膜を成膜した。

【００２９】次に図５（ａ）に示すように、ベース基板用の被成形用ガラス基板５０（例えば屈折率ｎ１＝１．５、熱膨張係数７０×10^{-7}／Ｋ、厚さ２ｍｍ、縦１０ｍｍ×横５ｍｍ）を用意し、前述したプレス型（図示せず）の下に被成形用ガラス基板５０が位置するよう固定する。次に被成形用ガラス基板５０とプレス型とを加熱し、被成形用ガラス基板５０を例えば７００℃で加熱軟化させてプレス成形を行う。この結果、図５（ｂ）に示すように、光ファイバを固定するためのＶ字状の固定溝５１が光ファイバ接合部として形成され、下部クラッド層の光学的接合面となる平面部５２と一体化されたベース基板５３が形成される。

【００３０】次に、予めコア部分に相当する線状凸部を

有する紫外線を透過する型（図示せず）を、以下の方法で作製する。例えば、厚さ５ｍｍ、縦５ｍｍ×横５ｍｍの石英ガラス基板を平面に研磨した後、通常のフォトレジストを用いたパターニング法により、コア部分のパターンを形成する。そして、ドライエッチング法を用いて石英ガラス基板の表面であってコアに相当する位置に、線状凸部（断面形状；高さ８μｍ×幅８μｍの突起）を２５０μｍ間隔で４本形成する。

【００３１】次に図５（ｂ）、（ｃ）に示すように、ベース基板５３の平面部５２に、屈折率ｎ２（ｎ２＝ｎ１）の紫外線硬化樹脂５４をスピンコーティングにより塗布する。そして紫外線を透過する型の表面に離型剤を塗布し、図２に示す紫外線硬化樹脂の硬化工程に用いた紫外線照射装置２０に設置する。このとき、固定溝５１の中心線と線状凸部の中心線が一致するように、紫外線を透過する型２１をガイドを用いて固定する。この状態で、上ブロック２３、下ブロック２２の間に設置し、上ブロック２３を徐々に下降させ、圧力を加えて押圧する。図2に示したような型２１の線状凸部２１ａの先端が、図５（ｄ）に示すように、ベース基板５３における下部クラッド層５９となる部分の表面に接するまでプレスを続ける。

【００３２】そしてそのままの状態で型の裏面から、上ブロック２３に内蔵した紫外線の光源２４を点灯し、紫外線を照射して紫外線硬化樹脂５４を硬化させ、型２１を離型させる。その結果図５（ｄ）に示すように、下部クラッド層５９の上面に、コアと同一厚みで、コア部分に相当する溝部５５ａを有する中間クラッド層５５が形成される。

【００３３】引き続いて、形成された溝部５５ａに対して、図６（ｅ）に示すように紫外線硬化樹脂５４よりも屈折率が０．３％程度高い屈折率ｎ３を有するエポキシの透明樹脂を埋め込んでコア５６を形成する。更にその上部から、図６（ｆ）に示すように、屈折率ｎ４（ｎ４＝ｎ１）の平面ガラス基板を上部クラッド層５７として貼り合わせ、ベース基板５３に光ファイバ接合部と光導波路基板とを合体した状態とする。このようにして光ファイバ接合部と、下部クラッド層５９、中間クラッド層５５、コア５６、上部クラッド層５７からなる光導波路基板とを有する光導波路部品を作製した。

【００３４】本実施の形態の製造方法により作製した光導波路部品では、帯状の中間クラッド層５５がコア５６を介して互いに分離され、更に下部クラッド層５９に強固に接着されている。このため、紫外線を透過する型と中間クラッド層５５と、コア５６の材料との収縮差によるパターンずれが非常に小さくなり、紫外線を透過する型の形状をそのまま良好に転写することができる。しかも、光ファイバを固定するためのＶ字状の固定溝５１が、光導波路基板のコアと高精度に位置合わせされているので、光ファイバを固定溝に並べるだけで、容易に光導波路部品を分波器等に組み込むことができる。

【００３５】（実施の形態３）次に本発明の実施の形態３における光導波路基板の構造とその製造方法について、図７～図１０を用いて説明する。図７は光導波路基板の製造方法を示す工程図である。図７（ａ）に示すように、屈折率ｎ１の平面ガラス基板からなる下部クラッド層７１を用意する。次に図７（ｂ）に示すように、下部クラッド層７１の光学的接合面に屈折率ｎ２（ｎ２＞ｎ１）の紫外線硬化樹脂７２をスピンコーティングにより塗布する。

【００３６】一方、コア部分に相当する位置に線状凹部が形成された紫外線を透過する型（図示せず）を用意し、紫外線硬化樹脂７２を型で押圧し、型の裏面より紫外線を照射して、紫外線硬化樹脂を硬化させて、図７（ｃ）のように互いに独立した帯状のコア７３を複数本形成する。次に図７（ｄ）に示すように、コア７３の部分を包み込むように屈折率ｎ３（ｎ３＜ｎ２）を有する樹脂を塗布することにより、上部クラッド層７４を形成する。そして図７（ｅ）に示すように、上部クラッド層７４上に保護用平面ガラス基板７５を接合することにより、構造の光導波路基板が得られる。

【００３７】図８は、本実施の形態の製造方法に於いて、紫外線硬化樹脂の硬化工程に用いる紫外線照射装置８０の構造を示す断面図であり、硬化前の状態を示す。この紫外線照射装置８０は、実施の形態１の紫外線照射装置と同様に、上下動可能な上ブロック８１と、固定の下ブロック８２を有し、上ブロック８１には、紫外線を発生する光源８４が内蔵されている。

【００３８】紫外線を透過する型８３は、コア部分に相当する位置に線状凹部８３ａを有するものである。この線状凹部８３ａは、実施例では、厚さ５ｍｍ、縦５ｍｍ×横５ｍｍの石英ガラス基板を平面に研磨した後、通常のフォトレジストを用いたパターニング法により形成された。また、石英ガラス基板に対して帯状のパターンを形成した後、ドライエッチング法を用いて石英ガラス基板表面に線状凹部８３ａ（断面形状；深さ８μｍ×幅８μｍの突起）を２５０μｍ間隔で４本設けた。

【００３９】次に厚さ２ｍｍ、縦５ｍｍ×横５ｍｍの平面に研磨した平面ガラス基板（屈折率ｎ１＝１．５、熱膨張係数７０×10^{-7}／Ｋ、耐熱温度７００℃）を下部クラッド層７１として用意し、下ブロック８２に載置した。そして屈折率がｎ１より０．３％程度高い屈折率ｎ２を有する紫外線硬化樹脂７２を平面ガラス基板の上面に、スピンコーティングにより塗布した。続いて、前述した石英ガラス製の型８３を紫外線硬化樹脂７２の上面に載せた。図８はこの状態を示す。

【００４０】次に、上ブロック８１を徐々に下降させて圧力を加えて押圧した。図９に示すように、石英ガラス製の型８３の先端が、下部クラッド層７１を形成する平面ガラス基板の表面に接するまで押圧を続け、紫外線の

光源を点灯させ、型８３の裏面より、紫外線を照射した。紫外線硬化樹脂７２が硬化したところで、型８３を離型した。この状態で図７（ｃ）に示したように下部クラッド層７１上に４本のコア７３が形成された。実施例では、各コア７３が２５０μｍ間隔で分離され、更に下部クラッド層７１に強固に接着された。このため、紫外線を透過する型８３とコア材料とのパターンずれが非常に小さくなり、型８３の形状をそのまま良好に転写することができた。

【００４１】引き続いて、下部クラッド層７１と同一屈折率を有するエポキシ樹脂をコア７３を包み込むように塗布して上部クラッド層７４とし、更にその上部から保護用平面ガラス基板７５を貼り合わせ、図１０に示すような光導波路基板を作製した。

【００４２】この光導波路基板は、樹脂を上部クラッド層７４とし、平面ガラス基板を下部クラッド層７１とし、紫外線硬化樹脂をコア７３とし、更に、上部クラッド層７４の上に保護用平面ガラス基板７５を備えた構造となっている。このように上下の平面ガラス基板により、エポキシ樹脂からなる上部クラッド層７４を強固に挟み込んでいるので、周囲環境の温度変化による形状変化はほとんど生じないことが判った。従って、この光導波路基板は十分な実用性を備えていると言える。

【００４３】（実施の形態４）次に本発明の実施の形態４における光導波路部品の構造とその製造方法について、図１１及び図１２を用いて説明する。まず、超硬合金素材を用いてプレス型（図示せず）を製作する。プレス型には、光ファイバを固定するためのＶ字状の固定溝と、光導波路基板を形成するための平面部とを一体化するようプレス面を形成しなければならない。実施例で用意したプレス型は、超硬合金素材に加工を施し、Ｖ字状の固定溝に対する型として線状山型突起を複数本形成し、更に、その横に平面部を形成したものであった。プレス型の外形は厚さ１０ｍｍ、縦１０ｍｍ×横５ｍｍの寸法を有するものとし、線状山型突起の間隔は２５０μｍで４本形成した。このプレス型のプレス面に離型用保護膜として貴金属合金膜を成膜した。

【００４４】次に図１１（ａ）に示すように、被成形用ガラス基板１１０（屈折率ｎ１＝１．５、熱膨張係数７０×１０$^{-7}$／Ｋ、厚さ２ｍｍ、縦１０ｍｍ×横５ｍｍ）を用意し、前述したプレス型の下方に固定した。そしてプレス型を加熱し、被成形用ガラス基板１１０を７５０℃で加熱軟化させてプレス成形を行った。この結果、図１１（ｂ）に示すように、光ファイバを固定するためのＶ字状の固定溝１１１と、光導波路基板を形成するための平面部１１２とが一体化されたベース基板１１３が形成された。

【００４５】次に、予めコア部分に相当する位置に線状凹部を有する紫外線を透過する型（図示せず）を以下の方法で作製した。厚さ５ｍｍ、縦５ｍｍ×横５ｍｍの石英ガラスの基板を平面に研磨した後、通常のフォトレジストを用いたパターニング法により、コア部分が溝となるパターンを形成した。そして、ドライエッチング法を用いて石英ガラス基板の表面であって、コアに相当する位置に線状凹部（断面形状；深さ８μｍ×幅８μｍの突起）を２５０μｍ間隔で４本形成した。

【００４６】次に図１１（ｂ）、（ｃ）に示すように、ベース基板１１３の平面部１１２（光学的接合面）上に、ｎ１より０．３％程度高い屈折率ｎ２の紫外線硬化樹脂１１４をスピンコーティングにより塗布した。そして線状凹部を有する紫外線を透過する型の表面に離型剤を塗布し、図８に示した紫外線照射装置８０にセットした。このとき、固定溝１１１の中心線と溝部の中心線が一致するように紫外線を透過する型をガイドを用いて固定した。この状態で、下ブロック８２の上面に載置し、上ブロック８１を徐々に下降させ、圧力を加えて押圧した。図８に示す石英ガラス製の型８３の先端面が、図１１（ｄ）に示すベース基板１１３の下部クラッド層１１６の部分の表面に接するまで押圧を続けた。

【００４７】そしてそのままの状態で、紫外線の光源８４を点灯させ、石英ガラス製の型８３の裏面より、紫外線を照射し、紫外線硬化樹脂１１４を硬化させ、コア１１５を形成し、型８３を離型した。この結果、図１１（ｄ）に示すように、下部クラッド層１１６の光学的接合面に４本のコア１１５が形成された。

【００４８】引き続いて取り出した基板全体に対して、図１２（ｅ）に示すように、下部クラッド層１１６と同一屈折率ｎ３のエポキシの樹脂をコア１１５を包み込むように塗布して上部クラッド層１１７を形成した。更にその上部から保護用平面ガラス基板１１８を貼り合わせ、図１２（ｆ）に示すように、光ファイバ接合部と、下部クラッド層１１６、コア１１５、上部クラッド層１１７からなる光導波路基板とを有する光導波路部品を作製した。

【００４９】本実施の形態の製造方法により作製した光導波路部品は、図１２（ｆ）に示すように、４本のコア１１５が互いに分離され、更に下部クラッド層１１６に強固に接着されている。このため、紫外線を透過する型とコア材料とのパターンずれが非常に小さくなり、紫外線を透過する型の形状をそのまま良好に転写することができる。しかも、光ファイバを固定するためのＶ字状の固定溝１１１が高精度に光導波路基板のコアと位置合わせされる。このため、光ファイバを固定溝１１１に並べるだけで、容易に光導波路部品を分波器等に組み込むことができる。

【００５０】

【発明の効果】本発明によれば、紫外線を透過する型と紫外線硬化樹脂の間では、紫外線照射による紫外線硬化樹脂の硬化工程で発生する収縮によるパターンずれを著しく小さくできるため、効率良く精度の高いコアパター

ンの形成が可能となる。従って、安価な光導波路基板及び光導波路部品を効率よく製造することができる。また、本発明の光導波路基板及び光導波路部品は、周囲温度の変化に対する形状変化が小さくなり、非常に信頼性の高いものが得られる。

【図面の簡単な説明】

【図１】本発明の実施の形態１における光導波路基板の製造方法の概略工程を示す断面図

【図２】実施の形態１の光導波路基板の製造に用いられる紫外線照射装置において、紫外線を透過する型をセットした状態を示す概略断面図

【図３】実施の形態１の光導波路基板の製造に用いられ紫外線照射装置において、紫外線硬化樹脂の硬化工程が完了した状態を示す概略断面図

【図４】実施の形態１の製造方法で製造された光導波路基板の断面構成図

【図５】本発明の実施の形態２における光導波路部品の製造方法の概略工程（その１）を示す斜視図

【図６】実施の形態２における光導波路部品の製造方法の概略工程（その２）を示す斜視図

【図７】本発明の実施の形態３における光導波路基板の製造方法の概略工程を示す断面図

【図８】実施の形態３の光導波路基板の製造に用いられる紫外線照射装置において、紫外線を透過する型をセットした状態を示す概略断面図

【図９】実施の形態３の光導波路基板の製造に用いられる紫外線照射装置において、紫外線硬化樹脂の硬化工程が完了した状態を示す概略断面図

【図１０】実施の形態３における光導波路基板の断面構成図

【図１１】本発明の実施の形態４における光導波路部品の製造方法の概略工程（その１）を示す斜視図

【図１２】実施の形態４における光導波路部品の製造方法の概略工程（その２）を示す斜視図

【図１３】従来の一般的な光導波路基板の断面構成図

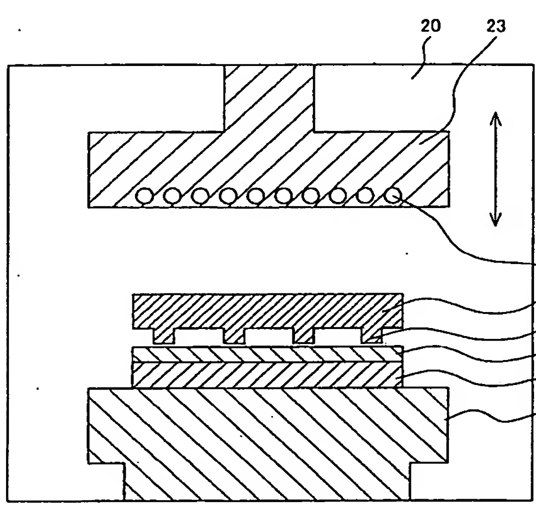
【図１４】従来の一般的な光導波路基板の製造方法の概略工程を示す断面図

【図１５】従来のプレス成形による光導波路基板の製造方法の概略工程を示す断面図

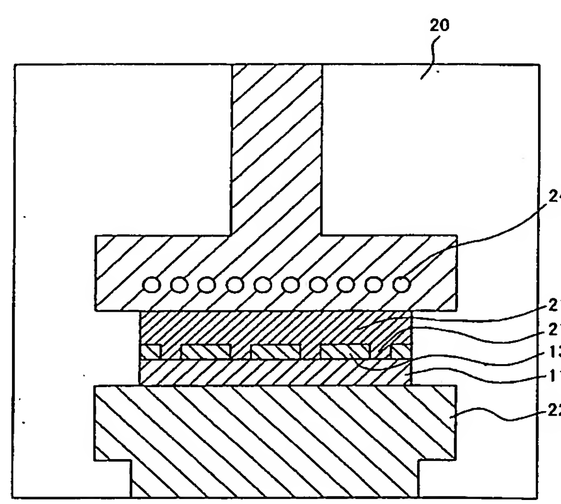
【符号の説明】

１１，５９，７１，１１６　下部クラッド層
１２，５４，７２，１１４　紫外線硬化樹脂
１３，５５　中間クラッド層
１４，５５ａ　溝部
１５，５６，７３，１１５　コア
１６，５７，７４，１１７　上部クラッド層
２０，８０　紫外線照射装置
２１，８３　紫外線を透過する型
２１ａ　線状凸部
２２，８２　下ブロック
２３，８１　上ブロック
５０，１１０　被成形用ガラス基板
５１，１１１　固定溝
５２，１１２　平面部
５３，１１３　ベース基板
７５，１１８　保護用平面ガラス基板
８３ａ　線状凹部

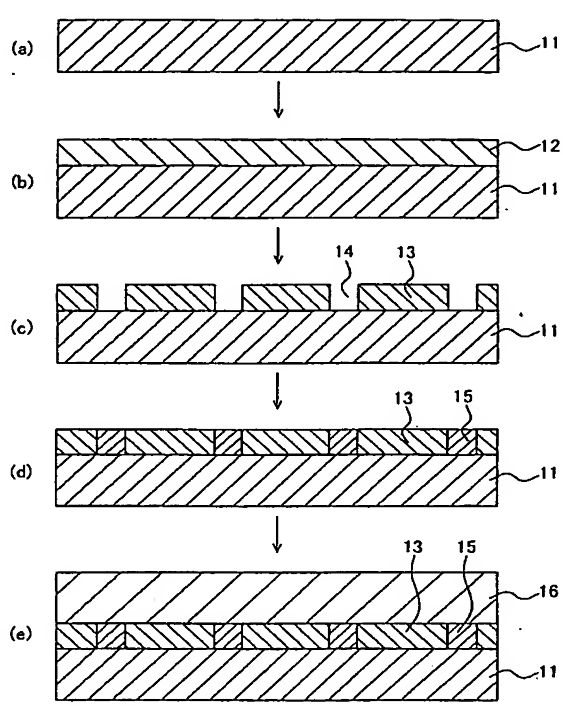
【図２】



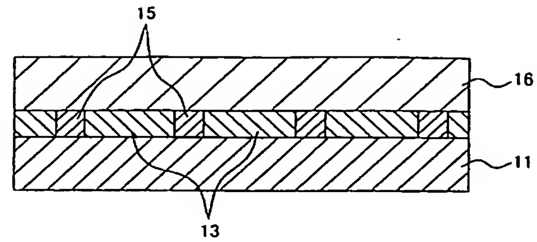
【図３】



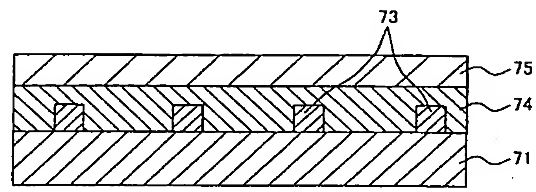
【図１】



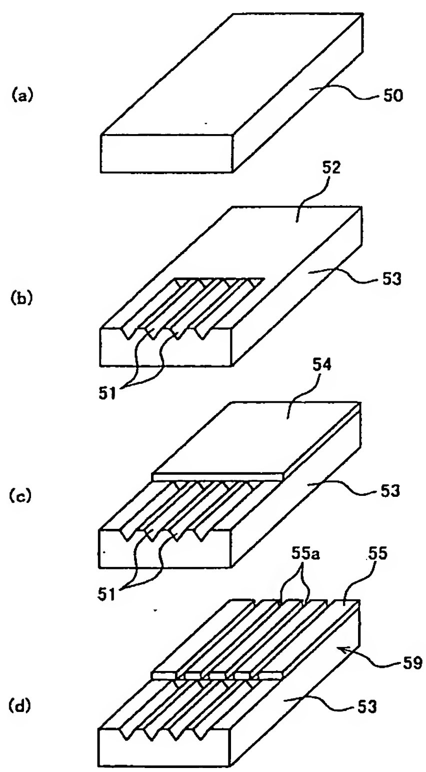
【図４】



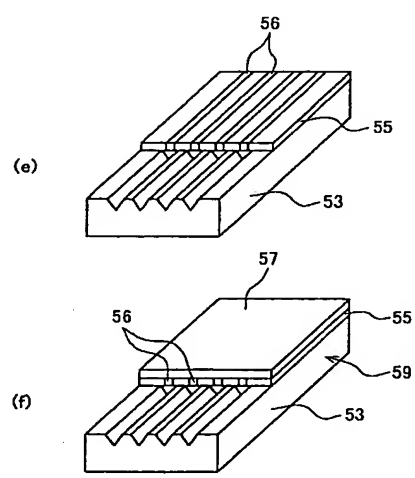
【図１０】



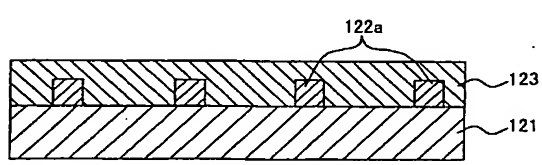
【図５】



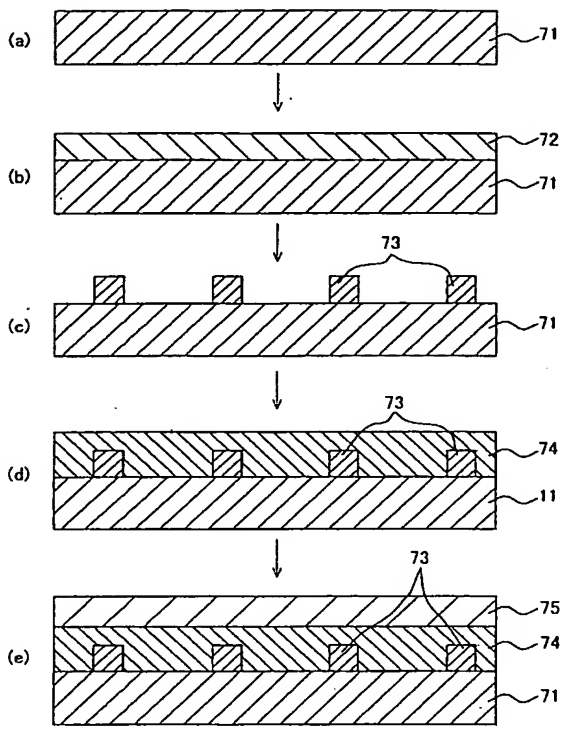
【図６】



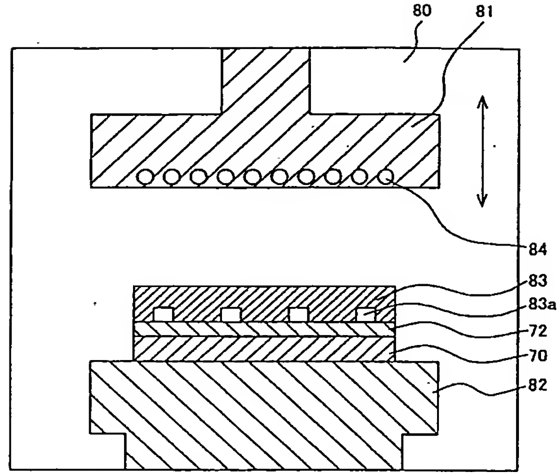
【図１３】



【図７】


(a)
71
(b)
72
71
(c)
73
71
(d)
73
74
11
(e)
73
75
74
71

【図８】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81
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83
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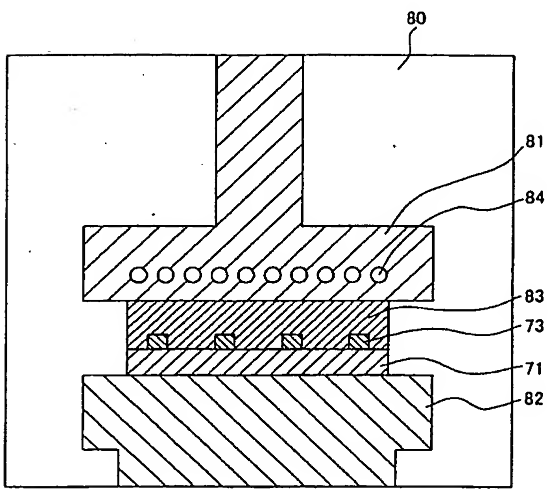
70
82

【図９】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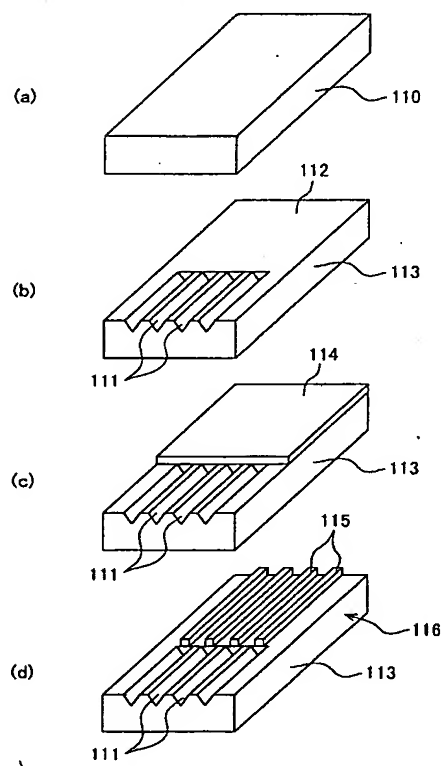
81
84
83
73
71
82

【図１１】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(c)
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111
(d)
115
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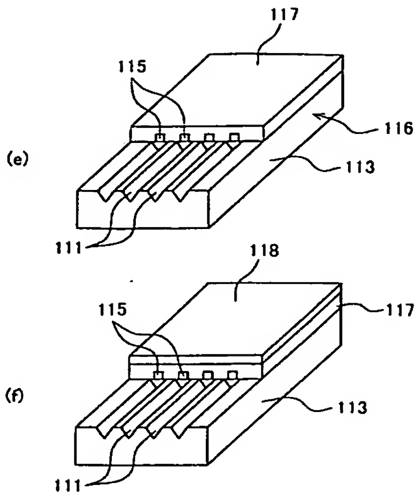
113
111

【図１２】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(e)
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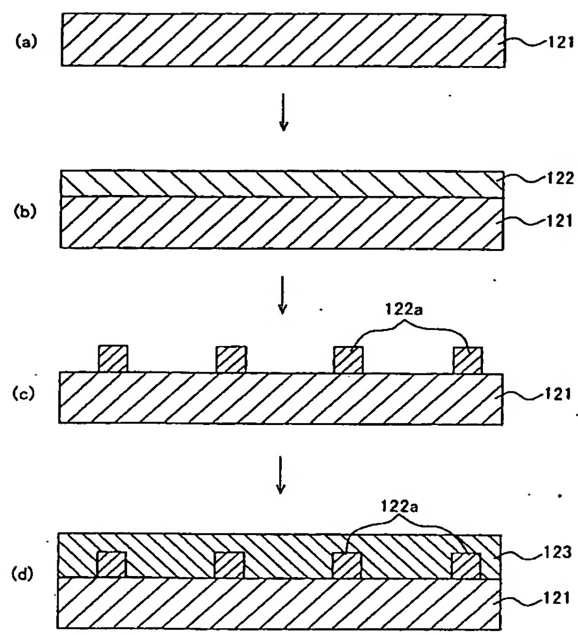
115
117
(f)
113
111

【図１４】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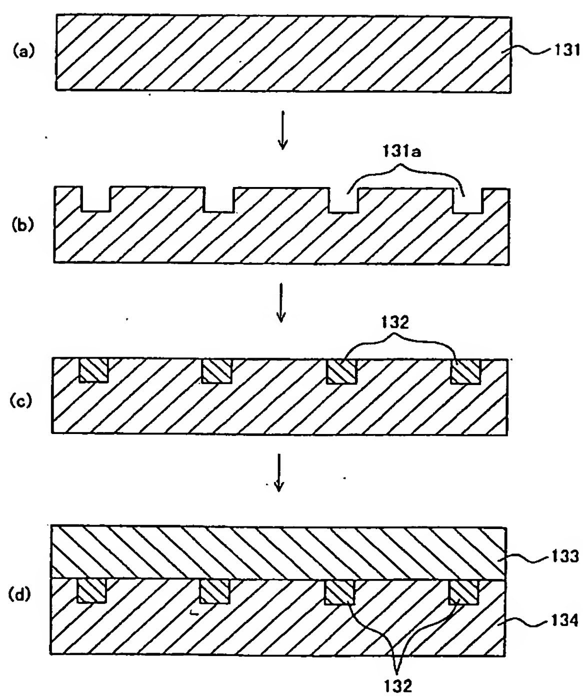
121
122a
(c)
121
122a
(d)
123
121

【図１５】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131a
(b)
132
(c)
(d)
133
134
132